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GEORGIA ACADEMY OF SCIENCE

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FIRE'S ROLE IN FOREST MANAGEMENT[1]

ROBERT W. COOPER

Southeastern Forest Experiment Station

Fire has been recognized as one of the first great forces employed by man. Even though actual evidence concerning the use of fire by the first humans is scarce and indefinite, the role that fire has played in agricultural development and the advancement of civilization is well documented. Nevertheless, its role of destruction and forest denudation cannot be overlooked.

People in the South have practiced woods burning for centuries. Early settlers had to clear ground for farming and livestock, as well as urban development. Thick forests and dense jungles of brush offered very little to the hunter or the stockman, so he set fire to the woods to "open them up." Unfortunately, however, these fires were seldom controlled and as a result they often left a path of destruction and devastation in their wake.

About half a century ago the citizens of this country realized the full scale destruction of forest wealth that was taking place, and American Forestry got its start under this impetus. Modern civilization demanded fire control for the protection of its property and the past fifty years have seen tremendous improvements in this direction. Complete fire exclusion, however, has brought about changes in stand composition in the pine and pine-hardwood stands of the South, many of which may not be desirable if optimum stand production is to be achieved. The Southern pines are essentially a fire sub-climax, although the extent of the great pine belt has led to the assumption that they are climax in nature. Dense hardwood understories develop gradually but rather persistently in pine stands which are free of fire. In addition, the absence of fire permits the accumulation of tremendous quantities of flammable fuels in the form of pine needles, grasses, leaves, twigs and branches, and weeds and shrubs, like palmetto and gallberry. As much as 25 tons of combustible material per acre is not unusual. Wild fires that start under these conditions spread rapidly and are difficult to control.

After careful study, foresters have concluded that all use of fire in the woods is not evil. In fact, the custom of woods burning in the South was undoubtedly based on shrewd observations, even though application was often carried to extremes.

Let us examine briefly the roles that fire may play in forest management of today and tomorrow. To do so, however, we must first agree on the meaning of a fire prescription. Prescribed burning has been defined as "the application of fire to land under such conditions of weather, soil moisture, time of day, and other factors that will allow confinement of the fire to a predetermined area and

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1. Read at Georgia Academy of Science Meeting Biology Section, Mercer University, April 1959.

at the same time will produce the intensity of heat and rate of spread required to accomplish certain planned benefits to one or more objectives." Some typical objectives are:

1. Hazard reduction
   Under carefully selected weather conditions, prescribed fire may reduce or temporarily eliminate accumulated fuels without serious injury to the timber stand. Techniques and practices have undergone considerable trial and error in the Coastal Plain flatwoods to the extent that fire has been generally accepted as a practical economical tool. General recommendations call for back burns against a steady wind on cool days during the dormant season.
2. Seedbed preparation
   Pine seed germinate best in mineral soil. A prescribed fire prior to seed fall reduces the vegetative and litter competition and permits the seeds to reach mineral soil.
3. Planting site preparation
   Through the wise use of fire, planting sites are made more accessible and easier to plant, the area is essentially fireproofed for the first year, and competition for water and nutrients is reduced.
4. Sanitation burning
   Prescribed burning is the most economical means of eradicating brownspot needle disease from longleaf pine seedlings. Where the disease is prevalent and some form of control is not practiced, seedling growth is poor and death often follows.
5. Control of undesirable species
   Most of the hardwoods that encroach upon the piney woods are inferior to pine in growth, form, and value. If the correct use of fire is prescribed before these hardwoods get out of control, hardwood invasion can be checked and optimum growth potentials can be realized. In addition, natural pine regeneration may be more readily established when the harvest cut is made.
6. Habitat improvement and grazing
   Winter burns temporarily provide advantages for cattle during the early spring months by increasing the protein and phosphorus content of the grasses two to three times. Fires are also being used to increase food supply and provide more open areas for wildlife.
7. Preparation for naval stores
   In order to minimize the fire hazard during a naval stores cycle, it is advisable to prescribe burn a sale area before the first cups are hung.

These examples of fire use illustrate the role that fire is playing in the management of Southern forests today. There remain, how-

ever, many unsolved problems concerning the effectiveness, limitations, and dangers of a prescription as complex as fire. The type of fire and the conditions under which it should be used vary with each one of the reasons for burning. For example, a cool burn is usually adequate for hazard reduction purposes while a hot fire is generally necessary for the control of undesirable species. One of our jobs at the Southern Forest Fire Laboratory is to find the solution to these problems through a realistic approach to the study of fuels, weather, topography and associated fire behavior.

The past century has indeed experienced a general change in our attitude toward the use of fire—from one of free burning and indifference regarding control, to one of complete protection and fire exclusion, and finally to one of wise use and control. Fire has already played an important role in the management of our timber resources but its role in years to come should be one of even greater significance.

THE SAPROLEGNIACEAE OF CLINCH COUNTY, GEORGIA[1]

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Water molds belonging to the Saprolegniaceae have been subjected to extensive taxonomic and distributional study in both Florida and North Carolina. Considering the ubiquitous nature of the water molds and the interest they have elicited from mycologists in these nearby states, it is surprising that we have so little information available on the water mold flora of Georgia. There are a few records of collections made within the state (Coker, 1923; Coker and Braxton, 1926; Harvey, 1930) but they yield no information on species prevalence or general distributional patterns in a well defined and limited area. The present communication represents the first report of a systematic investigation of the occurrence and distribution of the Saprolegniaceae in any area in Georgia.

Clinch County, in southwest Georgia, is well suited for a study of aquatic fungi. The northwestern portion of the county lies within the physiographic division of the Coastal Plain which has been variously termed the Altamaha Uplands (Veatch and Stephenson, 1911) and the Claxton Terrace (Cooke, 1925). This region is one of gently rolling to flat pine woods with an underbrush of saw palmetto, *Serenoa repens* (Bartr.) Small, and wire grass, *Aristida stricta* Michx. In Clinch County, at the lower limit of the Altamaha Uplands, considerable swamp land is also characteristic. Drainage streams in the northern and northwestern portions of the county have narrow, swampy areas along their courses and in some places expand into broad swamplike depressions which are termed bays or flats. The larger southern sections of the county lie within the Okefenokee Plain (Veatch and Stephenson, 1911) or the Okefenokee Terrace (Cooke, 1925). This region is the flattest of the coastal terraces, with a southeastward slope of but two feet per mile and, for the most part, is poorly drained. Consequently, the area is characterized by moist flats of pine, saw palmetto, and gallberry, *Ilex glabra* (L.) Gray, dotted with small cypress ponds and swamps. These swamps vary in size from a few acres to the vast Okefenokee Swamp, with an area of about 700 square miles, extending into the southeastern portion of the county. These numerous swamps, bays, ponds, flats, and sluggish streams make Clinch County an ideal area for the study of aquatic fungi.

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1. This paper is based on a portion of a thesis submitted to the Graduate School, Florida State University, in partial fulfillment of the requirements for the degrees of Master of Science in Botany.

2. Present address: Duke University Marine Laboratory, Beaufort, South Carolina.

Collecting and Culture

Two series of systematic water and soil sample collections were made in Clinch County, the first in late summer and the second in early winter. The samples were taken from 125 predesignated points widely distributed over the county. Each of the sampling points (with rare exception) was located either at a stream comprising a part of the drainage system of the county or in a cypress swamp or bay. Such locations were chosen primarily because they would likely be wet throughout the year and thus provide essentially comparable habitats despite the time interval between the two series. The collection of samples at the same stations during different parts of the year was undertaken to determine whether or not the Saprolegniaceae showed a seasonal periodicity.

From 50 to 200 cc. of water were collected in wide-mouth 8 oz. bottles on each visit to the sampling sites. At the same time, approximately five to ten tablespoons of moist soil, placed in 8 oz. plastic-coated moist-food containers, were collected at each station. For each of the two sampling series 250 water and soil samples were taken. The samples were returned to the Mycological Laboratory, Florida State University, for culture and identification.

The culture methods used in this study were essentially those reported by contemporary students of the aquatic fungi: Beneke (1948), Couch (1927), Johnson (1956), Sparrow (1943), Ziegler (1952) and others. The water samples were poured into 16 oz. wax-covered Dixie Cups or the type widely used for dairy products. The soil samples were cultured for water molds in the same plastic-coated containers in which they had been collected. This use of plastic and wax-covered cardboard containers for collecting and culturing the fungi is the only modification that was made in the culture methods used by the aforementioned workers. Distilled water, filtered through animal charcoal and sterilized, was added to the soil samples and was used throughout the study to replenish all water lost through evaporation. After the soil and detritus had settled, split seeds of *Cannabis sativa* L., hemp, were added to the samples as "bait." Seven days proved to be an adequate time for water molds to develop on the "bait." Fungi could usually be seen on the seed halves at the end of twenty-four hours and, generally, after two to four days each seed was surrounded by a thick mat of white hyphae. At this time the seeds were transferred to sterile Petri dishes and washed thoroughly with sterile distilled water. New hemp seed halves and fresh distilled water were added to these cultures. As the fungi grew on these new hemp seed halves they were observed daily, since the sexual and asexual reproductive structures serving as taxonomic criteria at different times, necessitating periodic observations of the cultures if correct identifications are to result.

In cases where two or more species of water mold were present on one hemp seed half, it was necessary to have unifungal cultures

before the water molds could be positively identified. For the most part these cultures were obtained by removing a single hyphal strand with oogonia from each of the species present in the original culture and placing it on maltose-peptone agar in a Petri dish. After the fungus had grown several days, small blocks of agar containing growing mycelium were transferred to sterile Petri dishes. Hemp seed halves and sterile distilled water were added. As soon as the fungal growth was evident on the hemp seed, the agar block was removed from the dish, the distilled water changed, and new hemp seed halves added. This method, while admittedly not as exacting as those methods used by Couch (1927), Harvey (1925), and Shanor (1937), is adequate for the isolation of cultures of these fungi for identification purposes.

Taxonomic Study

During this study a total of 500 water and soil samples, 250 of each, was collected in Clinch County. Of the 500 samples, 136 did not yield species of the Saprolegniaceae. Twenty of the 136 yielded aquatic fungi of other families and 116 were negative. From the 364 samples positive for Saprolegniaceae, 442 isolates were identified either to genus or species. A total of fifteen isolates in the genera *Achlya, Geolegnia,* and *Aphanomyces* did not form sexual reproductive structures and therefore were identifiable to genus only.

Identification of the water molds found in Clinch County was facilitated by the taxonomic keys available in various monographic and distributional treatments of the family. The principal keys utilized were those of Beneke (1948), Coker (1923), Coker and Mathews (1937), Gilman (1945), Johnson (1956), and Ziegler (1952). For detailed descriptive information and keys for the identification of the genera and species comprising this family of fungi, the reader is referred to the above mentioned studies, especially those of Coker (1923), Coker and Mathews (1937), and Johnson (1956).

Distribution and Frequency

The distribution and frequency of the water molds found in Clinch County are presented in table 1 below. With the exception of *Saprolegnia ferax* (Gruith). Thuret which was found near Dublin by Harvey (1930), all of the species listed in table 1 are new records for Georgia. The frequency column gives the total number of times each species was found in the county. The column headed Distribution and Remarks gives data on the distribution of the individual species in the county. The occurrence of a species primarily in the northern part of the county is indicated simply by the word "north." A similar designation is used when the species was more common in the southern, western, eastern, and central parts of the county. The term "widespread" indicates equal distribution over the entire

TABLE 1.—DISTRIBUTION AND FREQUENCY OF SAPROLEGNIACEAE IDENTIFIED FROM CLINCH COUNTY, GEORGIA

Species	Frequency	Distribution and Remarks
Saprolegnia		
diclina	14	Rare south, widespread elsewhere; winter series.
delica	6	Widespread; winter series only.
ferax	39	Widespread; winter series.
litoralis	16	Rare south, widespread elsewhere; winter series only.
monoica var. *glomerata*	6	Widespread; winter series only.
megasperma	3	West; winter series only.
Isoachlya		
intermedia	14	Rare south, widespread elsewhere; winter series.
unispora	2	North; winter series only.
eccentrica	1	North; winter series.
Achlya		
colorata	21	Widespread; winter series.
treleaseana	52	Widespread; winter series.
dubia	14	Rare south, widespread elsewhere; summer series.
inflata	5	West; summer series.
proliferoides	39	Widespread, both series.
orion	3	West; both series.
prolifera	23	Widespread; both series.
americana	7	Widespread; both series.
klebsiana	1	Northwest; summer series.
flagellata	95	Widespread; both series.
conspicua	1	North; winter series.
caroliniana	1	West; winter series.
recurva	1	Central; winter series.
crenulata	1	Northeast; winter series.
sp.	9	Central; summer series only; no oogonia produced.
Aphanomyces		
sp.	3	Central; no oogonia produced.
Thraustotheca		
clavata	3	North; summer series.
primoachlya	1	East; summer series.
Dictyuchus		
monosporus	37	Widespread; both series.
missouriensis	3	West; summer series.
pseudodictyon	18	Rare south, widespread elsewhere; both series.
Geolegnia		
sp.	3	Scattered; winter series.

county. The collection series of the samples from which the species was most frequently isolated is also given under Distribution and Remarks. The phrase "winter series" means that the species was isolated in more than 70% of the cases from samples taken during the winter collection series; "summer series" indicates a frequency of more than 70% in the samples from the summer collecting series. The phrase "both series" designates cases in which a species was not overwhelmingly restricted to the samples collected during one or the other of the two series but rather was about equally distributed between them.

The data presented in table 1 show that Clinch County has a very diverse water mold flora. The northern and western portions of the county show the largest number of species. The higher elevations and better drainage of these regions might account for a wider distribution of the water molds, although nothing can be presented to substantiate such a view. That there were more collecting stations located in the northern portions of the county certainly has some significance regarding the results presented in table 1. The inaccessability of large areas in the vicinity of the Okefenokee Swamp in the south made such an unbalanced distribution of collecting stations necessary. However, the number of stations in the north is not sufficiently greater than the number in the south to explain satisfactorily the fact that the northern regions showed not only a more diverse water mold flora but also a larger number of the total of 442 isolates. No explanation of this can be offered from the data presented here.

Table 1 also shows that the largest number of species was found in Clinch County during the winter collecting series. This would seem to support a view that some of the Saprolegniaceae do exhibit a seasonal periodicity. Ziegler (1958) has recently noted what appears to be a seasonal periodicity in the distribution of water molds in Florida. The data on seasonal distribution which were gathered during the course of this investigation are currently under study. It will suffice to say here that one will in every probability find a more diverse and truly representative water mold flora in the extreme southeastern United States if sampling and culturing are carried out during the cooler months of the year.

SUMMARY

A systematic investigation of the occurrence and distribution of the Saprolegniaceae in Clinch County, Georgia, is presented. A total of 442 isolates representing seven genera and twenty-eight species in this family were cultured from 500 water and soil samples collected in Clinch County at seasonal extremes. The species found are tabulated the data are included regarding the frequency and distribution of each of them. Evidence is presented which seems to support the view that the Saprolegniaceae exhibit a seasonal periodicity in the extreme southeastern United States.

ACKNOWLEDGMENTS

I am indebted to Dr. A. W. Ziegler, who directed this study, for his guidance and interest in the project. I am grateful to Dr. T. W. Johnson, Jr., Dr. Leland Shanor, and Dr. R. K. Godfrey for their reading and criticisms of the manuscript. The use of equipment granted to Dr. Ziegler under NSF Grant #2013 is also gratefully acknowledged.

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STUDIES ON HELMINTH PARASITISM OF FERAL SWINE IN GEORGIA

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Despite the potential economic importance of feral swine, *Sus scrofa*, and their apparent significance to agriculture and conservation, studies on the diseases of these animals have been limited. Recently, Hanson and Karstad (1959) in a discussion on the biology of feral swine, included a brief report on ecto- and endoparasites. The observations and studies on helminth parasitism in this paper constitute a continuation of the investigations initiated by these authors.

The writers extended their appreciation to the following persons: Mr. A. P. Cannon, Georgia State Game and Fish Commission, and to the personnel of the 714th Preventive Medical Company, Fort Stewart, Georgia, for their sincere efforts and cooperation in making pigs available; to Dr. R. P. Hanson, University of Wisconsin, for supplying parasite materials and for reviewing the manuscript.

MATERIALS AND METHODS

Parasites and materials for histopathological studies were collected from 49 sexually mature feral swine, captured on coastal islands of the Altamaha Delta (Butler and Champney Islands) and on the U. S. Army Reservation, Fort Stewart. Necropsies were performed either in the field or in the laboratory. Helminths were fixed in either A.F.A. (alcohol-formalin-acetic acid) or 10% formalin solutions. Nematodes were studied after being cleared in glycerine or lacto-phenol. Other helminth materials were stained in aqueous alum cochineal or Semichon's acid carmine. Tissues for histological sectioning were stored in 10% formalin or Bouin's fixatives and later stained with haematoxylin and eosin or Shorr's trichrome stains. Examinations for trichina larvae were accomplished by the press and pepsin-digestion techniques, although the former method was more frequently employed.

OBSERVATIONS AND DISCUSSIONS ON HELMINTH PARASITISM

I. NEMATODA

Ascaris lumbricoides Linn., 1758

From his studies on domestic pigs in the United States (principally from southern Georgia and Florida), Spindler (1934) observed *Ascaris* to be the third most common parasite found. He recovered

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TABLE 1

SUMMARY OF HELMINTH PARASITES COLLECTED FROM 49 FERAL SWINE OF THREE LOCALITIES IN GEORGIA, 1957-1959

Helminth	No. Hosts Infected	Extent of Infection*	% Infected
Nematoda:			
Ascaris lumbricoides	12	light-moderate	24.5
Globocephalus urosubulata	2	light	4.1
Hypostrongylus rubidus	2	light	4.1
Metastrongylus apri	30	light-moderate	61.2
Stephanurus dentatus	42	moderate-heavy	85.7
Strongyloides ransomi	5	light	10.2
Trichuris suis	6	light	12.2
Trematoda:			
Pseudospelotrematoides sp.	1	light	2.0
Fibricola sp.	1	light	2.0
Acanthocephala:			
Macracanthorhynchus hirudinaceus	8	light	16.3

*Light—less than 10 worms per host.
Moderate—less than 50 worms per host.
Heavy—more than 50 worms per host.

this nematode from the intestines of 74% of 348 hosts necropsied and infections ranged from 1 to 176 worms per animal. The relative incidence of infection in feral swine from localities in Georgia (table 1) was considerably lower than that reported by Spindler. We have found this parasite in 12 of 49 swine examined with infections ranging from 1 to 6 worms per animal. Exposure to infection (ground contamination) and the physiology of the host coupled with its genetic variation may be factors that could account for this difference in incidence. Unlike domestic pigs, feral swine are not restricted to confined quarters and therefore the possibility of acquiring infection is greatly reduced. The suggestion that limited acquired immunity against ascaris results from previous infections, has been put forth by numerous investigators (Stewart, 1916; Fülleborn, 1920; Hadwen, 1925). Ransom and Foster (1920) indicated that age may be a determining factor that causes lessened susceptibility of pigs to ascaris. This could be another reason for our low incidence of infection, although some of the hogs examined were judged to be less than one year of age.

Although certain definite pathology has been associated with ascaris parasitism, our studies did not reveal any serious condition which could be attributed directly to infection by this parasite. Histopathological study of the liver of one pig, revealed several

larvae, possibly ascarids, within blood vessels (figure 1) and focal areas of leuckocytic infiltration. Sections of the lungs of this pig, as well as those of many others, showed thickening of alveolar walls and many ruptured alveoli. No ascarids, however, were observed in the lungs, although other helminth parasites were seen in this organ.

FIGURE 1. *Some helminth larvae within a hepatic vein; liver of feral hog. H & E stain,* X300.

Globocephalus urosubulatus
(Alessandrini, 1909)

G. urosubulatus was rarely observed in feral swine, having been recovered from the small intestine of only two animals, both of which were collected on Butler Island. Infections were light in each instance, one animal harbored three parasites and the other nine. It is presumed that the general pathology produced by this parasite is similar to that of other hookworms. Spindler (1942) stated, "In light infections the worms probably do little noticeable injury." *G. urosubulatus*, therefore, is not considered by us to be of great importance to the health of feral swine in Georgia.

Hypostrongylus rubidus (Hassall and Stiles, 1892)

This minute red stomach worm appears to be uncommon in both domestic and feral hogs of Georgia. In this study, the parasite was recovered only twice. Both animals were captured on Butler Island and each hog harbored four worms. Of the three species of stomach worms reported by Spindler (1934), *H. rubidus* was less common in occurrence than the other two (*Ascarops strongylina and Physocephalus sexalatus*) and was found in only 15% of the 348 animals examined. Although we observed a very slight erosion of the gastric mucosa at the sites in which the worms were located, it is doubtful that so few parasites could be of clinical significance to the hog. *H. rubidus* is considered to be primarily a parasite of young swine. Since the worm has a direct life-cycle, the free-ranging tendency of feral swine reduces the possibility of their acquiring massive infection by the larvae of this nematode.

Metastrongylus apri (Gmelin, 1790)

This parasite was reported from feral swine earlier as "probably *Metastrongylus elongatus*" by Hanson and Karstad (1959). Their material has been re-examined by us and the species confirmed as

M. apri (syn. *M. elongatus*). This parasite was commonly collected from the lungs of feral swine and is apparently widely distributed in Georgia, since Spindler reported its presence in 69% of domestic pigs examined. Studies on the etiology of infections were accomplished by numerous investigators including Schwartz and Alicata (1934), Alicata (1935) and Kates (1941). The parasite has been collected by us from the tranchea, bronchi, and bronchioles of feral swine from each locality. Large numbers of these thread-like worms (table 1), many of which were enmeshed in a mucous-like exudate, were recovered from most animals examined. Histopathological studies of lung material revealed extensive inflammatory changes as a result of infections. There was usually a peribronchial leukocytic infiltration and some desquamation of epithelial cells. The adjacent alveoli showed emphysema or atelectasis. The walls of some alveoli were greatly thickened and exhibited a heavy cellular response or

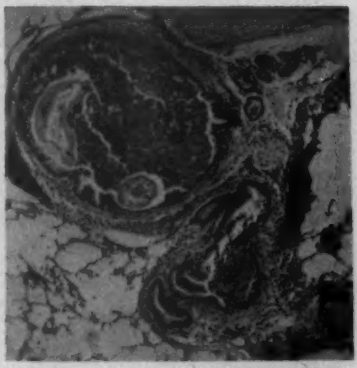

FIGURE 2. *Section of lung of feral hog showing adult M. Apri embedded in muco-cellular debris within a bronchiole. There is also disruption and thickening of alveolar septae and an embryonated M. apri (arrow) surrounded by histiocytes and leukocytes. H & E stain, X90.*

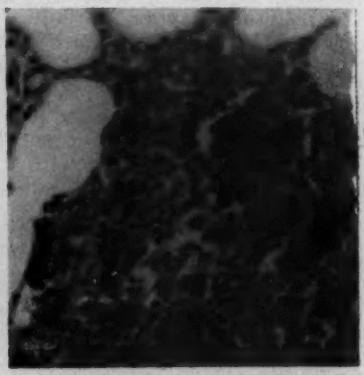

FIGURE 3. *Section of lung of feral hog to show lungworm larva in alveolar space surrounded by histiocytes, giant cells, neutrophiles and eosinophiles. H & E stain, X300.*

were completely desquamated (figure 2). In one instance, it appeared that several ova and larvae reached the alveoli, instead of being expelled via the bronchioles, bronchi, and trachea. A marked leukocytic response was produced in each case (figure 3). We have not found any report in the literature of this observation, although Baylis and Daubney (1923; cited by Baylis, 1936) mention that fragmentary materials of this species were recovered from the bronchi of a pig. Their observation suggests that the embryos could take either route,

however, the latter probably would be the more common one. Within the bronchi, sections of metastrongylids were frequently seen to be surrounded by a muco-cellular exudate (figure 2). Porter (1936) suggested that lungworms feed on such material. In several heavy infections a verminous pneumonia was directly attributed to *M. apri*. Inclement weather conditions and shortage of food, may be important factors in predisposing feral swine to verminous pneumonia.

Stephanurus dentatus (Diesing, 1836)

S. denatus was more commonly collected from feral swine in each locality than any other helminth, having been recovered from 85.7% of the pigs necrosied (table 1). Because of extremely heavy infections, in many cases accurate counts were not made due to the difficulty in obtaining the parasites. The percentage of swine found infected apparently closely parallels that (51%, liver and 88%, kidney) reported by Spindler. The maintenance of high frequencies of infection may be attributed to the parasite's earthworm-intermediate host. It is probable that helminths, such as the lungworm and the kidney worm, which have intermediate hosts would be more successful in maintaining a high infection-frequency in free-ranging swine than those parasites which have a simple and direct developmental cycle and depend upon the degree of ground contamination for successful transmission.

Although *S. dentatus* was collected more frequently from the kidneys (figure 4) and perirenal tissues, it was also observed encysted along the dorsal parietal peritoneum and lumbar tissues and within the pancreas, intestine, lymphnodes, lungs, and liver. Scars, such as described by Tromba (1955), were frequently observed on the latter organ. These lesions undoubtedly were due to *S dentatus*, since *Ascaris* infections were slight or absent. Invariably associated with the worm were accumulations of caseous material. Adhesions of parietal, pleural or renal surfaces commonly accompanied massive infections. Heavily parasitized vertebral columns of swine, as described by Raffensperger (1931), were observed by us on several occasions. Such pigs

FIGURE 4 *Kidney lesions produced by S. dentatus. Abscesses indicating parasite "tracts" are surrounded by zones of macrophage and fibroblast proliferation richly infiltrated with eosinophiles. Tubular structures are destroyed while glomeruli appear more resistant. H & E stain, X100.*

were emaciated and seemingly debilitated. Histopathological study of tissues from these infected animals showed extensive inflammatory lessons within every organ, including in one instance, the meninges of the brain. The major histopathological changes consisted of fibrosis and massive eosinophile infiltrates both in the vicinity of the parasitic cysts and along the course of migration of the parasites through the tissues. These changes were most striking in the livers of infected swine, where the condition might best be called parasitic cirrhosis. In the most severe cases the liver tissues contained numerous abscesses, which in histological sections were seen to consist of masses of dead or degenerating eosinophiles surrounded by a fibrous capsule (figure 5). Frequently, adult worms were found in the liver or lungs (figure 6) completely

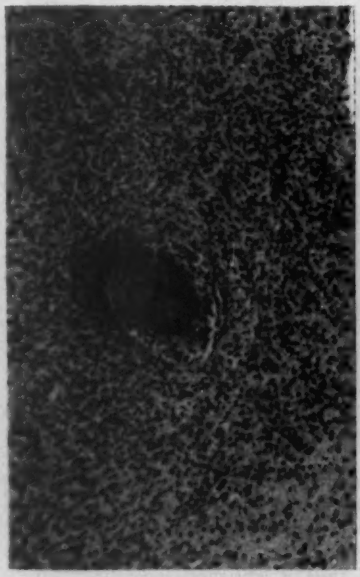

FIGURE 5. *Liver of feral hog with abscess produced by S. dentatus. The central caseous core is composed chiefly of dead eosinophiles. Surrounding this is a zone of histiocytes and giant cells followed by a zone of fibrous connective tissue infiltrated with eosinophiles. The remnant of a hepatic lobule to the lower left of the abscess shows evidence of pressure atrophy. H & E stain, X100.*

FIGURE 6. *Helminth, probably S. dentatus, within a blood vessel in the lung of a feral hog. The gut of the worm contains both erythrocytes and granulocytes. The vessel wall is stretched and surrounded by a heavy eosinophilic infiltrate. H &E stain, X100.*

surrounded by thick fibrous capsules. This tendency of *S. dentatus* to take up locations in other than the perirenal or periureteral tissues has been described by Mönnig (1947). Obviously, such errant migrants cannot discharge their eggs into the urinary tract. The serious prognosis of animals infected with this parasite has been reviewed by many investigators, including Price (1927), Spindler (1934; 1942), and vestigators, including Price (1927), Spindler (1934; 1942), and Morgan and Hawkins (1949). The natural conditions under which feral swine live negate simple artificial means of controlling infections by *S. dentatus*.

A more serious and economic implication of kidney worm infections in feral swine is the threat to the domestic hog population. Spindler (1942) stated that in the South, losses from trimming of infected carcasses and from condemnation of certain organs damaged by the parasite have been estimated at approximately 27% per animal slaughtered or 27 million dollars annually. Nightbert and Connelly (1928; cited by Morgan and Hawkins) estimated losses due to *S. dentatus* in a single Georgia packing house to be $80,000 per year. Perhaps a more important consideration than that of controlling parasites in the feral swine population per se, is that of the potential reservoir of infection from which domestic pigs may be infected. Since the open range system of hog management in Georgia is no longer legal, it is gradually being used less and less and better management practices are being put into operation. Economically, the future of this program could be seriously threatened unless parasitized feral swine are recognized as a potential hazard to the hog raising industry.

Strongyloides ransomi Schwartz and Alicata, 1930

S. ransomi was obtained from only five pigs, taken at Fort Stewart and Butler Island. The number of worms recovered ranged from one to eight. This incidence is probably of little significance since Spindler (1942) stated that these small roundworms burrow deeply into the intestinal mucosa and frequently may be over-looked unless special effort is made to find them. In addition to this, *S. ransomi* has been observed to infect primarly very young pigs, since healthy adult animals appear to be somewhat resistant to infection by this parasite. Spindler pointed out also that *S. ransomi* may be fatal to nursing sows whose vitality is depleted. Further investigation is warranted on the true incidence of infection in feral swine by this parasite.

Trichuris suis (Schrank, 1788)

Whipworms do not seem to be uncommon in feral hogs of Georgia, although the prevalence of infections by them appears to be relatively low compared with that (23%) of domestic pigs as reported by Spindler. We found this parasite in six or 12.2% of 49 animals

examined from two localities (Fort Stewart and Butler Island). The range of infection by this helminth was 3 to 7 worms per animal. Morgan and Hawkins (1949) pointed out that although the parasite embeds its anterior end into the intestinal mucosa, no noticeable pathology is produced. On the other hand, Spindler (1942) stated that massive infections noticeably retard the growth and lower the vitality of young swine and may eventually cause death. Somewhat similar observations on pathogenicity were made by Dr. A. C. Todd (personal communication) University of Wisconsin. Whipworms, therefore, are considered of clinical significance to the feral hogs of Georgia.

II. Trematoda

Pseudospelotrematoides sp.

Few trematodes have been reported from swine, *Fasciola hepatica* and *Paragonimus kellicotti* being the most common ones reported in parasitological literature. The feral pigs of the Altamaha Delta area commonly include in their diet fiddler-crabs, fish, earthworms, leeches, and gastrapods, some of which may serve as intermediate hosts for flukes. The feeding habits of feral swine have been reviewed by Hanson and Karstad (1959).

A single microphallid trematode was collected from the small intestine of a pig taken on Butler Island. Because of unsatisfactory staining, certain minor features of the male and female reproductive structures were not clearly discernable. However, F. J. Etges, University of Cincinnati, felt that because of the vitellaria and general characteristics of the worm that it could be assigned to *Pseudospelotrematoides* Yamaguti. Until additional specimens become available, species identification cannot be given. A brief description of the parasite, however, is included:

Pseudospelotrematoides sp.

(Figure 7)

Diagnosis: Body pyriform in outline, 0.286 mm. in length by 0.231 mm. in wdith. Pre-pharynx present. Pharynx 0.012 by 0.020 mm. Esophagus short, about 0.013 mm. in length. Intestinal ceca very short, extend to a point well anterior to acetabulum. Acetabulum in approximately middle of body, spherical, about 0.034 mm. in diameter. Male genital apparatus mostly anterior to acetabulum, not clearly discernable. Cirrus Present. Ovary large and spherical, in midline of body, slightly overlaps posterior margin of acetabulum. Dia-

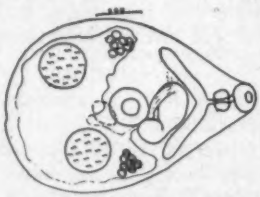

FIGURE 7. *Pseudospelotrematoides sp. (Diagrammatic drawing) — ventral view.*

meter of ovary about 0.043 mm. Tests oblique, in second half of body. Anterior testis overlaps posterior level of ovary. Posterior testis slightly below level of anterior one. Diameter of testes about 0.046 mm. Vitellaria in two groups with 7-9 follicles in each, in fields lateral to acetabulum. Egg-filled uterus occupies most of lower two-thirds of body space; descending limbs extends to anterior level of ovary, ascending limb reaches to genital pore at anterior margin of acetabulum. Average size of (50) eggs, 0.015 by 0.007 mm.

Fibricola sp.

Four specimens of a strigeid trematode of the genus *Fibricola* DuBois, 1944 were collected from the small intestine of a single pig, captured on Butler Island. We have not found any record of the occurrence of members of the genus in swine. The raccoons of this area are known to harbor *Fibricola* spp. and it is possible that the infected feral hog may have been an accidental host for this parasite. The feral swine specimens were turned over for study to Dr. Reinard Harkema, North Carolina State College. It is hoped that species-identification can be given at a later date.

III. ACANTHOCEPHALA

Macracanthorhynchus hirudinacea (Pallus, 1871)

This parasite was occasionally found in the small intestine of feral swine from all localities. The number of worms ranged from one to nine. The anterior end of each acanthocephalan parasite was deeply embedded in a small nodule which appeared on the mucosal surface at the site of attachment. In some cases the nodule appeared inflamed and a severe enteritis was present within the general area of attachment. Chandler (1956) stated that occasionally the worms may perforate the gut and precipitate a fatal peritonitis. Except for the localized conditions described, no other gross pathology was observed by us that could be directly attributed to this worm. Since intermediate hosts of *M. hirudinaceus* involve grubs, june bugs, and a wide variety of other arthropods, it is doubtful if natural infections in feral swine could be controlled.

SUMMARY

Feral swine from areas in Georgia were observed to be infected with several species of helminth parasites. The helminths recovered are as follows: NEMATODA: *A. lumbricoides, G. urosubulata, H. rubidus, M. apri, S. ransomi, S. dentatus,* and *T. suis;* TREMATODA: unidentified microphallid and *Fibricola* sp.; ACANTHOCEPHALA: *M. hirudinaceus.*

Although helminth parasites were invariably found in feral swine, the prevalence and number of species recovered were conspicuously low compared to those reported from domestic pigs of Georgia and Florida by Spindler (1934). The trichina worm, *Trichinella spiralis*, was not found, despite the use of a pepsin-digestion technique. No cestodes were recovered from the viscera nor the musculature. *M. apri* and *S. dentatus* were the most common parasites recovered and the pathology produced by these species appeared to be more serious than that caused by any other helminth. Unfavorable climatic conditions and malnutrition are undoubtedly important factors in predisposing feral pigs to parasitism. The natural conditions under which these animals live preclude any artificial means of controlling their helminth parasites.

The economic significance of feral swine as a reservoir of infection should be recognized, since swine management in Georgia is in a stage of vast improvement. It is conceivable that heavily parasitized feral swine could seriously jeopardize the health of domestic hogs, and perhaps other domestic animals, despite better management practices and the use of newer and more efficient anthelmintics. Cross transmission of parasites between animal species does not occur. It has been shown by Douvres and Tromba (1958) and Kennedy (1958) that certain swine parasites can infect cattle. The role that feral swine may play in this regard needs further investigation.

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A DESCRIPTION OF LOCKHEED'S GEORGIA NUCLEAR LABORATORY AND METHODS OF GROUND DISPOSAL OF LIQUID RADIOACTIVE WASTES

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USAF Contract No. 33(600)-32055

INTRODUCTION

The various facilities of Lockheed's Georgia Nuclear Laboratories (Air Force Plant #67) are directed toward providing design data for nuclear powered aircraft. The individual facilities are interdependent, and the combination of reactors and radiation laboratories generate relatively large volumes of low-to intermediate-level liquid radioactive wastes. Disposal of this material is by infiltration in the ground. The operation is controlled by the geological and hydrological factors. These factors have been investigated, and extensive safety precautions have been, and will continue to be, taken.

I. Site Description

The Georgia Nuclear Laboratory, AFP #67, is operated by the Nuclear Products Branch of the Georgia Division, Lockheed Aircraft Corporation, for the United States Air Force. The site consists of a 10,000 acre tract located in southeastern Dawson County, about 45 miles north of Atlanta.

The location is in the Piedmont Plateau Province, which contains foothills of the Blue Ridge Mountains. The site is characterized by steep hills and slopes, dense vegetation, and well-entrenched and down-cutting streams. Elevations onsite range from about 1,000 to 1,400 feet above mean sea level. Annual rainfall is in the order of 55 inches. The area is sparsely populated, with only about 200 persons living within a 3 mile radius of the main reactor. (5)

The Georgia Nuclear Laboratory (GNL) incorporates some features unique among existing or proposed experimental facilities for production of design data for nuclear powered aircraft. The primary objective of this facility is to test dynamically components and subsystems under realistic radiation fluxes. After irradiation, materials will be tested for physical damage and detrminations will be made on the possible amount and type of induced radiation due to activation by neutron bombardment.

The plant consists of four main facilities, the Radiation Effects Facility (REF), Radiation Effects Laboratory (REL), Critical

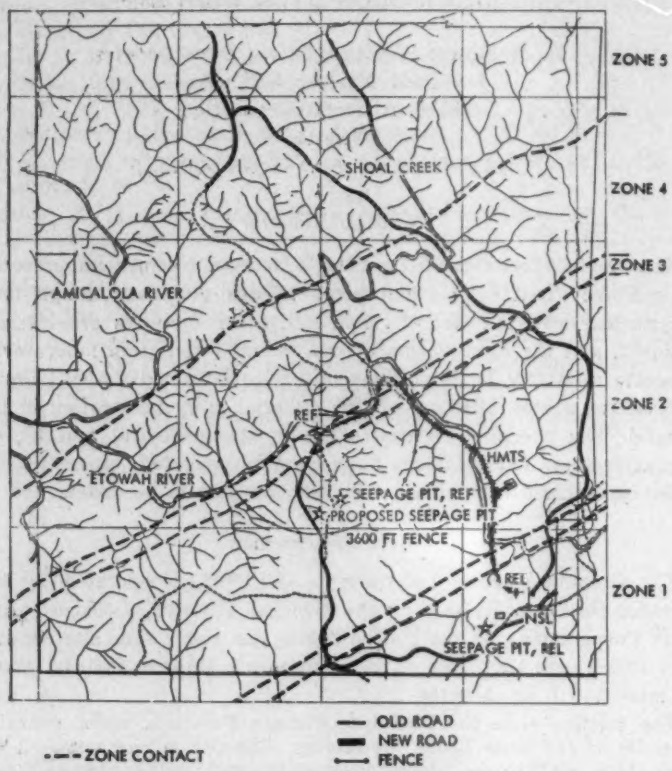

FIGURE 1. *AFP #67 Site Map showing Major Facilities, Waste Disposal Components, and Geologic Zones.*

Experiment Facility (CEF) and the Nuclear Support Laboratory (NSL). The location of these are shown in figure 1.

II. Radiation Effects Facility

The REF is centrally located on the site and is composed of the reactor building which houses the Radiation Effects Reactor (RER) and the operations building, from which all reactor operations and test monitoring is accomplished. The reactor building is above ground and the operations building is underground, as shown in figure 2.

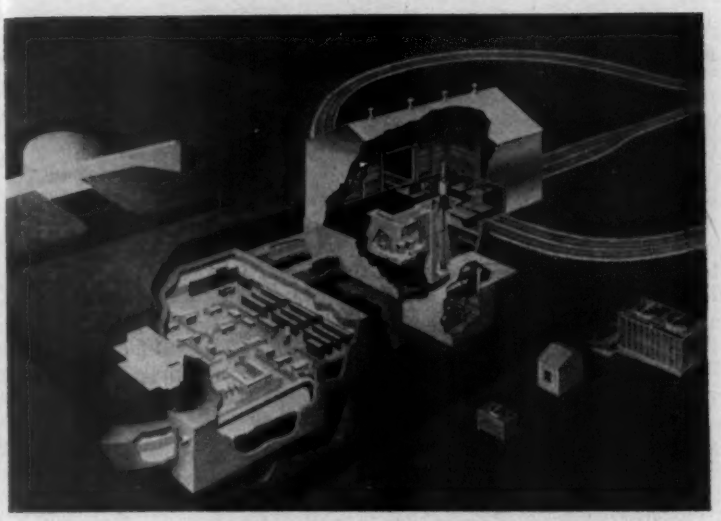

FIGURE 2. *Radiation Effects Facility.*

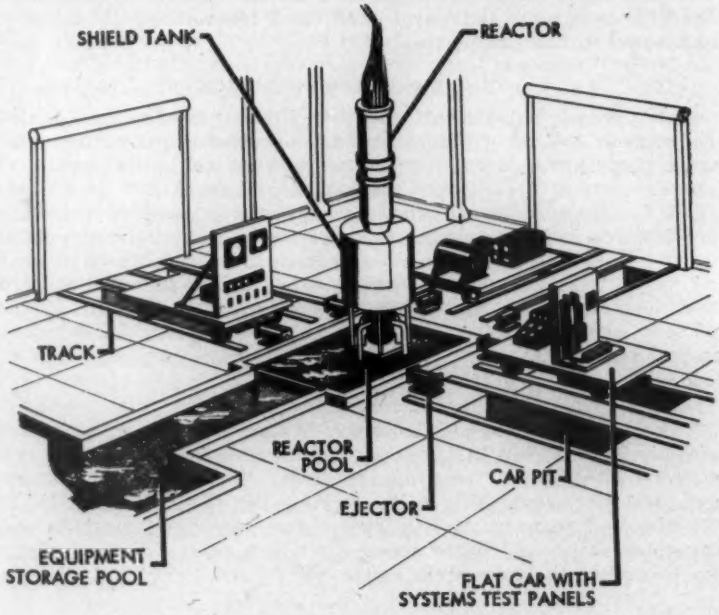

Figure 3. Radiation Effects Facility, Irradiation Test.

The RER is designed to operate at a maximum power level of 10 megawatts with an average thermal neutron leakage current more than 8 x 10^{11}, in order to provide realistic high radiation fluxes (3). Solid fuel is used containing highly enriched U^{235}. The reactor is pressurized light water cooled and moderated and when not in operation is lowered in a 57,000 gallon pool of water (5). A unique feature of the RER is that in its position for irradiation it is unshielded. This is the reason for the operations building being underground. Articles to be irradiated are brought into position on railroad cars. The railroad, which connects the REF and the REL, is part of the Hot Materials Transport System. When the test articles are in position the RER is raised out of the pool by a hydraulic lift and irradiation begins. Figure 3 shows the reactor in test position. All mechanical manipulations are effected from the operations building, and the events may be viewed by closed circuit television.

III. Radiation Effect Laboratory

After irradiation, the test articles are moved to the REL which incorporates the facilities for pre- and post-irradiation testing of the aircraft components and sub-systems. Still on the railroad cars, the irradiated articles are moved directly into heavily shielded hot cells, where remote manipulators are available for dismantling or for other operations on the articles. In addition to the hot cells, the REL houses hot and warm work areas, laboratories, the laundry, and experimental supporting facilities (4).

IV. Critical Experiment Facility

The Critical Experiment Facility (CEF) contains the Critical Experiment Reactor (CER). This is a low power (80 watts) swimming pool type reactor designed to perform criticality and other reactor physics experiments, with cores intended for use in the Radiation Effects Reactor. The internal components of these reactors are identical, thus providing a means for determining the relative worth of possible core and reflector geometries in a facility which allows ready access to these elements. This facility therefore permits both increased safety and economy by permitting criticality studies without consuming the valuable time in the high-flux RER experimental facility (3.

V. Nuclear Support Laboratory

The Nuclear Support Laboratory (NSL) is the focal point for administrative offices and services. The nuclear instrumentation lab, meteorological group, counting facilities, Nuclear Safety Department,and other supporting units are housed in the NSL. In addition, the fire and plant protection group, the warehouse, machine and carpenter shops, and water treatment and sewerage disposal plants are located in the same areas as the NSL.

VI. General Safety Considerations

In operating a plant of this nature, safety considerations for persons living in the area and employees are of high importance. All possible hazards generated by such an operation have been carefully evaluated, not only by Lockheed personnel, but by the Atomic Energy Commission and Air Force as well. Steps have been and will be taken to eliminate all such hazards in as far as is possible. The atomic energy industry has a safety record which can be envied by many of the other large industries.

VII. General Problems of Radioactive Waste Disposal

Many of the problems of safe and economical disposal methods of the radioactive wastes generated by the atomic energy industry have not yet been resolved. Radioactive particles cannot be "done away with." Nuclear fission produces material more insiduous than the parent. The natural decay of radioisotopes is the only method by which these elements may lose their activity; and the decay periods vary from less than one second to thousands of years. The average mixture of high-level fission product wastes would have to be stored for several hundred years before it could safely be released to the environment. During this storage period shielding or isolation is required to prevent personnel over-exposure. Under normal operations this type of high-level wastes will not be generated at the site. While the solution of the problem of disposal of low- and intermediate-level wastes is safe and relatively economical, no easy method of ultimate disposal of high-level liquids has been found at the GNL.

Radioactive wastes fall into the three major categories of gaseous, solid, and liquid. Gaseous contamination was a serious problem in the early days of air-cooled reactors, but recent improvements in filters have alleviated this hazard considerably. Airborne activity must still be carefully monitored in any radiation area. Often, special systems regulating air flow directions and efficient filtration must be provided. For example, air for the operations building at the REF is pumped in from a pipe extending 4200 feet from the reactor. With proper precautions, therefore, gaseous wastes problems are capable of being solved.

Solid radioactive wastes present different types of problems, but those too are not unresolvable. Proper shielding is the main consideration. Solids may be buried under carefully controlled conditions or as a comparable alternative stored in well-protected areas. Practical hazards are involved in personnel exposures during handling and transportation.

Liquids account for the most difficult to handle radioactive wastes. They are generally large in volume and hard to retain. Two main theories exist concerning this type waste: They are (1) concentrate and contain and (2) dilute and disperse.

Many methods exist under the concentrate and contain school of thought. Indeed the most widespread method of liquid radioactive waste disposal at present is tank storage. This is generally considered an interim solution, due to high initial expense and possible failure of tanks due to corrosion effects of many years. Other methods include evaporation of liquids, conversion of liquids to solids by ion exchange resins, calcination processes, formation of concrete, and others. Some of these processes create airborne contamination, and this as well as the solids formed involve other disposal problems. All of these methods are relatively expensive.

The dilute and disperse theory is obviously much more applicable to low- and intermediate-level wastes than for high-level wastes. Natural radioactivity occurs in all phases of the environment at background levels. Maximum permissible concentrations of radioisotopes in air and water have been established by the National Committee on Radiation Protection, made up of leading experts in the field. These concentrations are set so that if not exceeded, no detrimental effects will occur to the individual. Low-level and most intermediate-level liquid wastes may be diluted and dispersed into the environment by methods such that these recommended MPCs are not exceeded. These methods require careful environmental monitoring to ascertain that activity levels are not too high. Some low level wastes may be injected directly into surface streams and the ensuing dilution results in acceptable activity levels per unit volume. Low-

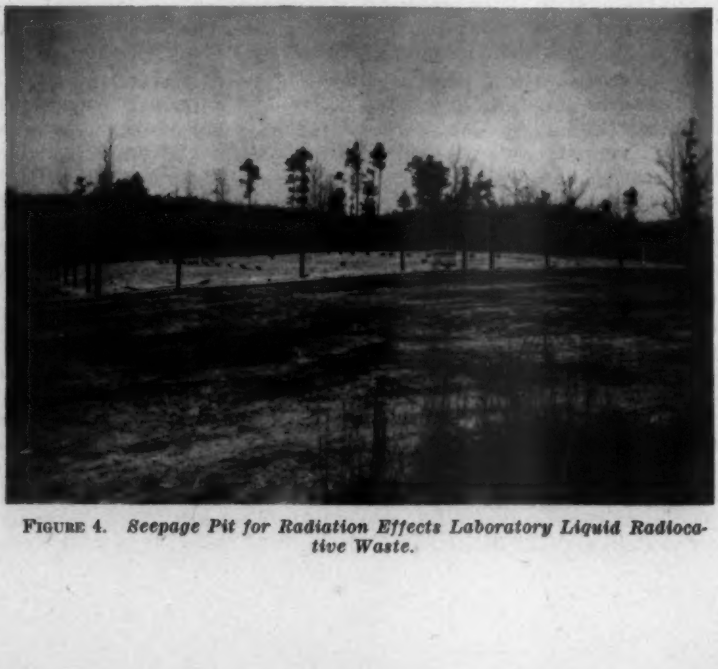

FIGURE 4. *Seepage Pit for Radiation Effects Laboratory Liquid Radioactive Waste.*

and intermediate-level liquid wastes may be pumped in seepage pits constructed in soil. These pits have proved to present substantial decontamination factors before wastes eventually reach surface streams (2). This is the method used at the GNL. One of the seepage pits is shown in figure 4.

The geological and hydrological aspects of areas using ground disposal of radioactive wastes are very important. Geological factors control the underground movement of wastes. They also influence many such aspects as ion-exchange and filtration capacity of soils, retention of radioisotopes in the space in crystal lattices of clay, and other related factors.

Hydrological considerations involve dilution and dispersion of liquid wastes in the ground water table and surface streams, the rate and direction of waste movement in the ground, capillary retention of wastes, testing of aquifers, and many other important parameters.

Detailed investigations have been conducted on the geology and hydrology of the GNL site since 1956 by United States Geological Survey and Lockheed personnel. This will be a continuing program.

An efficient radioactive waste disposal program also incorporates effective sanitary, mechanical, and chemical engineering aspects which are very important in the stage prior to ground or other ultimate disposal measures.

VIII. Radioactive Waste Disposal at Georgia Nuclear Laboratories

The coolant and pool waters of the reactors at GNL are deionized by several mixed bed demineralizers. The GER has one 17.1 cubic foot resin capacity demineralizer, and the RER uses a pool cleanup and a bypass demineralizer, both with an 18 cubic foot resin capacity. These effectively remove a large portion of the water impurities and corrosion products in the reactor wastes which would otherwise become activated by neutron bombardment. The RER also incorporates an 18 cubic foot capacity waste cleanup demineralizer. This will be effective in removing activation and fission products from the waste disposal lines, providing decontamination factors of 10^3 to 10^4 (3). Under normal operating conditions, fission products will not be released into the primary cooling system, but will be contained in the fuel elements. When these elements have expended their effective reactivity, thy will be returned to AEC fuel processing plants.

The REF waste disposal system as shown in figure 5 also contains two 5,000 gallon waste decay tanks and one 150,000 gallon hold and drain tank. The wastes in these tanks may be recirculated through the waste cleanup demineralizer.

The Nuclear Support and Radiation Effects Laboratories have a combined radioactive waste disposal system shown in figure 6.

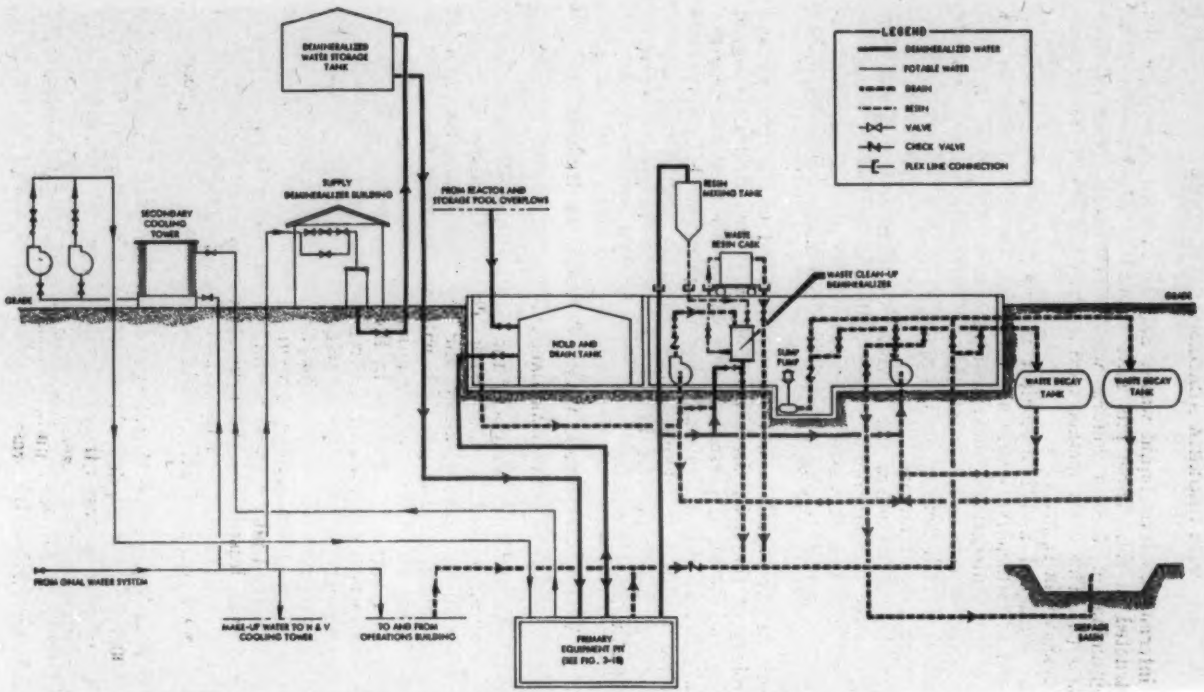

FIGURE 5. *Radiation Effects Reactor Waste Disposal System.*

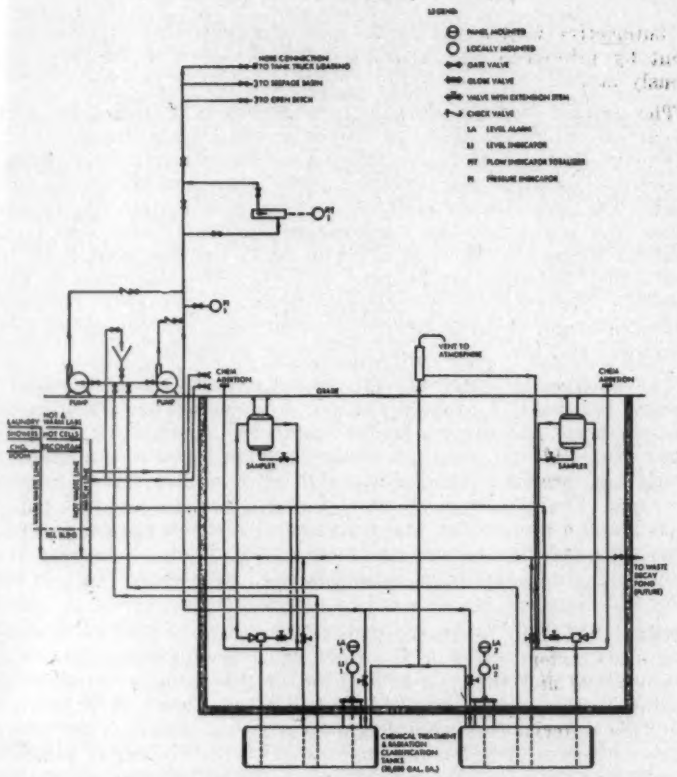

FIGURE 6. *Radiation Effects Laboratory Waste Disposal System.*

No demineralizers are provided, as the wastes are expected to be low-level. The main features of the system are the two 20,000 gallon hold tanks. Tank level indicators and integrated samplers are part of the system.

Wastes from the tanks at both the REF and REL can be pumped into nearby pits, which are similar in design, with approximately 100,000 gallon capacities. The sides are sloped about 1:2 and covered with coarse rip-rap. The bottom is graveled. The tops are covered with a screen to prevent contamination of birds or other animal life.

FIGURE 5. *Radiation Effects Reactor Waste Disposal System.*

IX. Geological Considerations

Radioactive wastes leaving the pits are controlled in their movement by geological and hydrological parameters, as has been previously stated.

The ground disposal of radioactive wastes to metamorphic rocks, as carried out at the GNL, is unique in the United States (3). The Piedmont Province of North Georgia is characterized by northeast-trending crystalline rocks. Two units of the Carolina gneiss occur onsite. The northwestern half of the area is underlain by a biotite gneiss and schist and the southeastern portion is occupied by the Ashland Schist (1) The age of these rocks has not been definitely established, but they are believed to be late Pre-Cambrian or early Paleozoic. Sedimentary and igneous origins of these rocks have been established, and they have experienced at least two periods of metamorphism and several periods of igneous intrusion (1).

Geological mapping of the lithological and structural features of the site has resulted in its division into 5 zones. These trend southwest-northeast and dip generally steeply to the southeast. Figure 1 shows the different zone divisions. Gneisses, schists, amphibolites, quartizites, granulites and other typical crystalline rocks compose the zones. The lithologies of zones 1 and 5 are similar, and that of zones 2 and 4 are similar. Many structural features are found in the rocks. The most prominent are four sets of joints. Foliation, axial plane and shear cleavages, relic bedding, and linear features also occur (1).

Alluvial deposits along the Etowah River are a distinct lithologic unit. These extend up to 30 feet thick and a few hundred yards wide. The physical and chemical breakdown of the fresh rocks onsite has resulted in the creation of a thick layer of weathered rock, or saprolite. This material is composed of clay minerals, and in it are located the seepage pits. The ion-exchange capacity of this soil is beneficial in retaining some of the radioisotopes contained in the wastes. Ion-exchange capacity determinations have been made on 123 samples collected from zero to 18 feet in depth. Results ranged from 2.5 to 13.7 milliequivalents per 100 grams and averaged 5.2 me/100g. Kaolinite is the most important mineral in the exchange process (6). While these figures indicate a relatively low capacity for base exchange, the tremendous quantities of soil involved provide an overall high efficiency.

Grain size determinations on soils from seepage pit areas indicate that 20 percent by weight is composed of clay-size particles less than 4 microns in diameter (6). It is believed that this will provide effective physical filtration for active particles in the wastes in the 4 to 40 micron range. Particles over 40 microns are filtered out of the primary coolant and pool systems of the RER. The REL waste system has no provision for filtration.

X. Hydrological Considerations

The Ground Water Branch of the U. S. Geological Survey has been investigating the hydrologic features of the site. They have completed an inventory of existing wells, collected water level data, and in conjunction with Lockheed have supervised and performed an extensive test-well drilling program. The present observation well inventory numbers more than 200, most of which are located in seepage pit areas. The U. S. Geological Survey has in addition performed many other tests and collected much information valuable to the waste disposal program.

The ground water onsite occurs under unconfined conditions. Bedrock is relatively impermeable, and most of the movement of the ground water takes place in saprolite. Tests have shown the coefficient of permeability of the saprolite near seepage pits as being 0.005 to 9 gallons per square foot per day. Estimated rates of ground water movement for both seepage pit areas have a maximum value of 1 foot per day. This is based upon the hydraulic gradient at each site, porosity of the saprolite, and maximum permeabilities (6). This rate under ideal conditions will afford several years in the ground prior to release of wastes to surface streams. During this period decay processes will be at work further reducing activity levels. This will be particularly beneficial for the common relatively short-lived activation products.

Ultimately wastes leaving the seepage pits will probably enter the Etowah River, which bisects the site, flowing west and providing drainage for the whole area. In addition to ion exchange, soil filtration, and decay processes due to relatively slow movement of wastes through the ground, dilution effects by surface and ground water will farther reduce the activity per unit volume of effluent. The Etowah River has a turbulent nature and offers a dilution of 22,500 gallons per minute (GPM) during lowest recorded flow conditions and 112,500 gpm during average flow. Preliminary tests have shown that ground water dilution is probably a factor of 4 or 5 to one.

XI. Maximum Permissible Concentrations

Maximum permissible concentrations have been established, which will conform with those set up by the National Committee on Radiation Protection, to determine the method of disposal. Liquid radioactive wastes containing between 10^{-5} and 10^{-7} microcuries per milliliter of unknown gross beta-gamma activity will be pumped into seepage pits. If the wastes contain less than 10^{-7} uc/ml, they may be released directly to surface streams. Before levels exceed 10^{-5} uc/ml, data will be available which may permit the release of higher activities to seepage basins. A considerable safety factor has been provided for environmental and seepage pit releases. It is expected that limits can be increased when data have been obtained from actual operating experience and functional seepage pit disposal.

Otherwise, liquids with greater than 10^{-5} uc/ml will be stored until decay has reduced activity levels, or they will be shipped for chemical processing elsewhere.

XII. Environmental Monitoring

Pre-startup environmental samples of soil, water, vegetation, and air have been collected for more than a year. This was done to determine background radiation levels so that any increase may be immediately detected. The Georgia State Health Department is monitoring the operation by sampling the Etowah River below the site, and it also plans to collect air, soil, and vegetation for analyses.

Water levels in seepage pit areas have been measured for over two years by the U. S. Geological Survey and Lockheed. The addition of large amounts of liquid to the water table can cause the buildup of a ground water mound under seepage basins. This in turn could cause the underground movement of wastes in new directions, and the steepened hydraulic gradient would result in increased velocity of the wastes. The background water levels obtained will permit this condition to be recognized quickly if it should occur.

The GNL radioactive waste disposal system is designed to efficiently and safely handle low- and intermediate-level wastes. The problem of high-level wastes is solved by shipping this material elsewhere for processing.

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A REPORT READ AT THE ACADEMY CONFERENCE,[1] WASHINGTON, D. C., DECEMBER 28, 1958

from

THE GEORGIA ACADEMY OF SCIENCE

WOOLFORD B. BAKER

When the Georgia Academy of Science was organized in 1922, its membership was restricted to the few professional scientists working in the major colleges and in one or two of the local industries. This policy of restricted membership was retained until 1932 when a program of expansion was begun.

The Academy was not divided into sections during the first few years. All members met together for presentation of papers, exchanging ideas and transacting business. The meetings were well attended and resulted in a wholesome synthesis of the different disciplines and the development of mutual understanding between the various scientists. Visiting scientists from other states were brought in to give us broader perspective and new viewpoints. The AAAS was our most important national organization and its annual meetings were attended by many of our members in spite of limited budgets and difficulties of travel during the holiday season.

With the development of separate organizations for the different sciences and the provision of better support for travel to meetings outside the state, the nature of the annual meetings of the Georgia Academy was changed. An attempt was made to encourage participation by graduate students and teachers from the smaller institutions. Membership was extended to amateur scientists and to non-professional individuals who were interested in science. The Academy was divided into sections and separate programs were arranged for each section. Although the Academy as a whole met for business sessions and for the annual banquet much of the closely knit fellowship which existed during the first years was lost.

In 1937 a movement was begun to extend the influence of the Academy to the High Schools of the state. Meetings were held with leaders from the secondary schools and the organization of a Junior Academy was initiated. Membership in the Senior Academy was extended to High School teachers, science clubs were organized and a liaison committee from the Senior Academy was set up to work with leaders in the Junior Academy. This plan has been followed consistently since 1940 with what we believe to be excellent results. Science fairs were sponsored with senior members acting as counselors, judges and members of committees to raise funds, provide meeting places and arrange for awards. A director of the Junior Academy was selected by the Senior Academy and was made a

1. The Academy Conference is part of the A.A.A.S. annual meeting.

member of the Academy Council. District fairs were held over the state and an annual state fair culminated the activities of the year.

A special Science Education section was set up in the Senior Academy and has proven very successful. The programs have been well attended and a better understanding has developed between the Senior and Junior members. The Senior members have become acquainted with the problems and needs of the science teachers in the secondary schools and the Junior members have come to realize that the Senior members are anxious and willing to help them in carrying on their work. Several direct and significant results have come from this type of mutual understanding.

1. Several members of the Academy were asked to serve on a committee appointed by the State Department of Education to study the status of science teaching in the public schools and make recommendations for improvement in both science and mathematics. Although the Academy was not officially involved in the work of the committee the individual members gave freely of their time and talents when called upon.

2. As a direct outcome of the report of the Science and Mathematics Committee made in 1951, the State Department financed an extensive curriculum study for the state and during the summers of 1957 and 1958 an effective curriculum for science from grades 1 through 12 was developed. Several of the members of the curriculum committee were members of the Senior Academy and the High School teachers involved were very active in the Junior Academy organization.

3. Acting upon the recommendation of the committee the State Board of Education provided funds for an extensive training program for the science teachers in both the elementary and high schools. During the summer of 1958 more than 600 scholarships were granted to teachers who took work at the different colleges of the state. Most of the courses were conducted by active members of the Senior Academy who had followed the course of the Academy activities with the public schools from the beginning. Seven hundred and fifty scholarships have been set up by the State Department for the summer of 1959.

4. Several members of the Senior Academy are conducting in-service courses for teachers in the Greater Atlanta area in connection with grants from the N.S.F. and subsidies provided by Emory University and the University of Georgia. Though this is not officially a program of the Senior Academy, the influence of the Academy is exerted in bringing to the fore-front the problems arising in the in-service courses as topics for discussion at the annual meeting of the Science Education section of the Academy.

5. Through the cooperation of Academy members, Sigma Xi and R.E.S.A. registers have been prepared of scientists who are willing to assist the High School teachers as consultants, lecturers, judges

in science fairs and congresses, and as sponsors for students in various talent search programs. This list has been widely distributed and many of the Academy members are participating in the program. Particularly interesting is the support being given by scientists in industry to this activity.

6. A list of all teachers of science in the High Schools of the state has been prepared together with the subjects taught and the number of pupils enrolled in each course. This makes possible a close correlation between the scientist on the register and the individual teachers who can use their services. The State Department of Education has appointed a full time science counselor, who with five traveling laboratories, is able to coordinate science instruction and implement the new science curriculum.

Although the nature of the activities of the Senior Academy has changed considerably since its foundation we believe it is able to serve the cause of science in the state much more effectively in the future by stimulating interest on the part of younger students and aiding the teachers in the public schools in strengthening the science curriculum.One of the most serious difficulties in carrying on such a program is the lack of adequate financial support. Since the financial support for all Senior and Junior Academy activities is derived from dues and special donations solicited annually from various sources there has never been enough available for necessary and desirable expansion. Four particular areas of activity need strong financial support:

1. Travel funds for the visiting lecturers, sponsors and judges now listed on the register of scientists. These individuals give freely of their time but few are able to assume the responsibility for any extensive travel in their desire to aid the teachers.

2. Regional meeting of teachers and interested students would augment our activities considerably and enable visiting scientists to multiply their contacts. Few of our teachers have funds for this travel.

3. The expense of our Bulletin is borne entirely by the subscriptions of members and a few libraries. Support for its enlargement and the addition of a newsletter that could be widely circulated to all science teachers and science clubs is urgently needed.

4. Travel funds for the Director of the Junior Academy, usually provided by the individual from personal funds, are insufficient for him to properly coordinate the work of the science clubs, stimulate interest in science on the part of the community and to use to best advantage the services of the volunteers from the Senior Academy.

A PRELIMINARY SURVEY OF VOICE VARIATIONS IN RATS AND THEIR GENE CONTROL

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Persons employing rats for scientific purposes may have observed that individual animals demonstrate distinguishable types of voice according to whether their vocal expression is occasioned by uneasiness, fear or anger, pain and sexual excitement. Female voices can sometimes be distinguished from those of males, and it is always noted how the faint, almost inaudible, high pitched squeak of the suckling rat is gradually transformed into the harsh, terrifying shriek of the mature adult. So far as we are aware, no one has attempted to analyze the "language of the rat," although such a "language" is undoubtedly capable of description.

The voice of the rat probably varies slightly with sex, more with the evoking situation and the most with age. Our studies, here to be described, add gene constitution as a fourth factor controlling audibly distinguishable voice differences in rats.

METHODS AND MATERIALS

In order to eliminate the possible differences due to sex, male rats only have been employed in this survey. To negate so far as possible the effects of age, only mature adults have been tested. That we might provide a uniform evoking stimulus for testing their voices, each animal was caught with a pair of tongs by the skin of the side or back and held suspended before the microphone of a sound prism (Schuck, 1934). If this procedure, which usually proved sufficient, failed to induce a cry, the rat was pinched at the base of the tail with a second pair of rat tongs.

We observe that under presumably the same stimulus of being picked up with forceps, one rat may merely whine a slight protest and make no attempt to escape, whereas another rat may shriek with rage, struggling and biting frantically for several minutes; another may emit a cry as of fear and struggle to escape without biting. We realize that in all future work it will be necessary to devise methods of producing, so far as possible, a uniform evoking stimulus to call forth the outcry. We believe that it is not always possible to elicit an outcry because some dwarfs, for example, could probably be slowly crushed to death without registering their objections vocally.

The test animals for which we obtained successful records belonged to strains as follows: black; pink-eyed yellow; black-eyed yellow; black piebald; all of tame laboratory stock in addition to the late

Dr. Helen D. King's wild gray Norway stock and its mutant derivative strains of: mutant albino; cinnamon; curly; stub tail. Two combination strains exhibiting two mutations each were investigated, namely: Ruby-eyed curly; and Black Curly.

Voice Characteristics and Recording Equipment

An analysis of the sound wave of a sustained tone, such as might be produced on a vibrating wire or string, shows that it will consist of components of various frequencies. These frequencies are all exact multiples of the lowest frequency present, which is known as the fundamental frequency. The other components are known as harmonics or overtones.

The human ear is sensitive to three general characteristics of sound. They are pitch, intensity, and quality. Pitch is determined by the frequency, high pitch corresponding with high frequency; intensity by the amplitude of vibration; and quality by the harmonic structure (number of components present and their relative amplitudes).

The sound prism used in this study is a device which will analyze a sustained tone giving the frequency and relative amplitudes of all components in one-tenth of a second. Thus a tone need only be sustained for that period of time to be accurately analyzed. However, by using an oscillograph in conjunction with the sound prism, successive analyses may be recorded photographically, so that variations of the sound with time may be noted.

In our experiments the sound wave was picked up by a microphone placed about one foot from the source, amplified, analyzed, and recorded on a rotating film drum, so that approximately fifteen successive analyses were obtained over a period of one and one-half seconds. The frequency range covered all components between 100 and 8,000 cycles per second, and relative amplitudes ranging approximately from 30 to 1 were observed. The accuracy of determining the frequency of any particular component is not better than plus or minus 50 cycles per second.

A preliminary study of our records indicated that it would be advisable to classify them according to (1) variations with time, (2) harmonic structure, and (3) frequency of fundamental.

All records showed variations with time. Some were relative-constant, however, over periods of one-half second or more, and these were placed in the sustained group. Others indicated that the sound existed only long enough to be recorded in one or two successive analyses and these were placed in the transient group. Records of sounds that existed for periods of time longer than several tenths of a second, but which exhibited important changes in frequency or in relative amplitude of the components, were placed in the varying group.

The harmonic structure determines the intensity and quality of the tone. This class was divided into two groups giving (a) the

number of harmonics present, and (b) the number of these harmonics which showed comparatively large amplitudes.

Although the fine details of such analyses are not always distinguishable to the human auditor, in a crude way he may be aware of some of these characteristics in a voice. For example, a simple, high-pitched, clear, whistle voice to the human ear would be found to possess one high fundamental frequency of larger amplitude, in addition to which there might be several harmonics of minor amplitude. The addition of harmonics may "improve" the "tone quality," on the other hand, a harsh raucous sounding cry, unlike a whistle, is more likely to be found transient, or varying. It will probably have a larger number of harmonics than the whistle-voice, but these will usually be of rapidly varying amplitude and frequency. The fundamental frequency may be low. Some of the fundamental frequencies have been placed on their appropriate positions on the diagram of a piano keyboard in figure 1. It will be seen that they are easily distinguishable to the human ear.

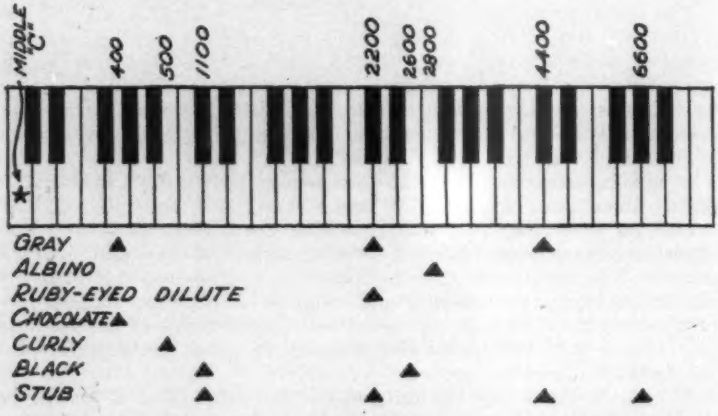

FIGURE 1. *Portion of a piano keyboard above which is indicated the frequency of pitch in vibrations per second. Below the keyboard is indicated by triangles the position of fundamental tone and overtones recorded on the sound prism for adult male rats of several inbred strains described in the text.*

ANALYSIS RECORDS

A number of direct auditory observations had been made upon animals belonging to various strains that had been employed for a study of the pleiotropic effects of coat color genes (Keeler and King, 1942; Keeler, 1947). These observations were as follows:

(1) Gray Norway rats have loud, raucous voices with low pitch.

(2) Curly rats have voices similar to those of gray rats but of less intensity.

(3) Mutant albinos have, in general, a whistle voice of high pitch.

(4) Stub tail rats, although having a voice of less intensity and of less purity of tone than mutant albinos, have a high pitch.

(5) Cinnamon rats have a voice similar to that of gray Norways.

(6) Pink-eyed yellow rats have a medium high pitched voice similar to that of black-eyed yellows.

(7) Black rats have a high pitched voice as do black piebald rats.

(8) Ruby-eyed curly rats have a medium pitched voice.

(9) Black curly rats have a low pitched voice.

Because of the preliminary nature of these observations, it is not to be assumed that they can serve as more than a guide for further work, and possibly they may not even represent accurately average descriptions of the voices of these strains when examined under controlled conditions.

They are, however, corroborated by our analytical check shown in table 1.

STRAIN OF RAT		GRAY NORWAY				CURLY			BLACK PIEBALD				MUTANT ALBINO					STUB		PINK-EYE CURLY	CINNAMON	BLACK	PINK-EYE YELLOW	BLACK-EYE YELLOW	BLACK CURLY
SPECIMEN NO.		1	2	3	4	1	2	3	1	2	3	4	1	2	3	4	5	1	2	1	1	1	1	1	1
TIME	TRANSIENT		X	X		X	(X)	X		X		X		(X)							X		X	X	X
	SUSTAINED	X			X	X	(X)		X		X		X	(X)	X	X	X	X	X	X		X				
	VARYING	X			X	X			X		X							X		X		X				
HARMONIC STRUCTURE	NUMBER OF HARMONICS	12	3	3	4	6-12	1	7	5	1	5	3	3	1	3	3	1	3	4	3	3	3	5	7	7
	NUMBER OF PEAKS	2	2	2	3	1	1	2	3	1	3	3	1	1	1	1	1	2	1	3	2	2	(3)		1
	VALUE OF PEAKS	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000	1000-6000			1000-6000
FREQUENCY OF THE FUNDAMENTAL	100-400 CYCLES	400	400	400	400	400	400	400		(400)											400					400
	400-1000 CYCLES		(1000)						1000		1000	1000						1000		1000			1000	(1000)	
	1000-2000 CYCLES												1000	1000	1000	1000	1000		1000			1000			

TABLE 1

Rat voices are analyzed as to (1) *variations with time,* (2) *harmonic structure, and* (3) *frequency of the fundamental length. Vertical columns represent the analyses with respect to these three qualities for a single specimen. Where parentheses are used, there is a question between two alternatives. Under time variations, an X mark indicates presence of a characteristic. Under harmonic structure with respect to number of predominant peaks, the small number* (1-3) *represents the actual number of such peaks whereas the larger number* (1000-6000) *represents the value of those peaks in cycles per second.*

From a sample of one mature adult male rat from each of the above mentioned strains we first obtained one or more clear analysis records on photographic film. From these we learned that, roughly, auditory impressions do separate gross voice differences.

We selected additional rats of the gray Norway, curly, black piebald, mutant albino, and stub tail strains for further study.

For each of these strains we may obtain voice records from the same individuals which indicate that the voice of a particular rat may be at one time sustained and at another time varying. For a single curly rat (specimen No. 1) we actually obtained records of transient, sustained and varying time quality. This lack of uniformity may be associated with the change of psychological motive, the intensity of the struggle to become free from the forceps, the tensed muscles of the throat and other physical factors. However, a tendency of the mutant albino voice to be sustained is apparent in our records.

When quality and intensity features of voice are examined, it is found that 12 harmonics are present in the record of one gray Norway rat; 8-12 in a curly rat; 7 in a second curly rat. It will be recalled that our general observation was that gray Norwalk and curly rats have raucous voices. In contrast, the number of harmonics is from 1 to 3 in mutant albino rats that have clear "musical" voices. The intermediate types in voice quality (black piebald and stub tail) may have more than 3 and less than 6 harmonics in our sample. Black piebalds tend to have 3 predominant peaks, gray Norway 2, Curlys 1 or 2, stub 1 or 2, but mutant albinos have but one predominant peak. As a result, the mutant albino voice has a whistle quality.

The most constant feature, and one distinguishable to the human ear, is that of the fundamental frequency observed. And it will be remembered that fundamental frequency determines pitch.

All four gray Norway rats tested had a fundamental between 400 and 500 cycles per second, denoting a relatively low pitched voice. All three curlys tested had a fundamental at 500. Three black piebalds had a fundamental at 1000, indicating a medium pitched voice, but one black piebald, also exceptional with respect to number of harmonics, had a voice, the fundamental of which varied between 500 and 800. Five mutant albinos had a high fundamental ranging from 2200 to 2700. There was a suggestion that the fundamental of one of those recorded at 2200 may possibly have been at 1000. These records denoted a very high pitched voice. Of the two stub tail rats for which we have adequate records, one had a fundamental at 1000 and one at 1900, indicating medium high and high pitched voices respectively. Variability in stub rat voices is to be anticipated because the stub tail gene dwarfs the individual animals in various degrees.

Corroborating the auditory impressions of low pitch, we find that gray Norways and curlys have low fundamentals (400-500), black piebalds, with their medium pitched voices, have medium range fundamentals (about 1000), whereas stuf-tail rats and mutant albinos, with their recognized high pitch of voice, may have high range fundamentals (1900-2700). (See figure 1)

Genetic Implications

Because of the inbreeding inherent in the gray Norway strain (King, 1939), it is evident that in general, single-gene-mutant derivative strains will bear much the same residual hereditary background, and hence we may consider most of the idiosyncracies of the mutant derivative strains when compared with the gray Norway source strain as a standard, as being direct effects of the coat-color genes, that mark them.

Upon this reasoning we may say that the curly gene probably tends to lower the voice as does the cinnamon gene. We may suggest that the voice of black animals (not having the gray Norway background) tends to be high in the one case studied. This tendency may be due to the black gene.

When the black gene was combined with the curly gene, we find that a low-pitched voice resulted. It would seem that here the low pitched tendency of the curly with fundamental at 500, dominates in such a combination over the high-pitched voice of the black with fundamental at 2800.

But when Ruby-eye is combined with curly, the fundamental frequency of the voice is raised in the double recessive to 1000.

Stub-tail raises the fundamental frequency to 1000 or more, in our second case, to 1900.

The mutant albino gene raises the fundamental pitch enormously, that is, from the 500 cycle fundamental up to from 2200 to 2700. That this characteristic, clear, whistle voice with very high fundamental, actually segregated together with the albino gene is suggested by the fact that among albinos appearing in later generations from a cross of Wistar albino (purebred for black and piebald) to gray Norway, there were found several animals having the unique, high, clear whistle voice of the mutant albino.

We admit the meagre nature of the direct genetic data, and hope that these suggestions may be checked by future tests upon a significant number of individuals.

DISCUSSION

Voice is a measurable function of structure, and hence our survey suggests that the development of comparable vocal organs together with comparable methods of employment are actually the physical entities determined by the presence or absence of various single genes.

A cursory examination of the vocal organs was undertaken for each of the animals tested. This revealed the curious fact that although there may be some correlation between characteristic strain voice and shape of epiglottis, similar voices within a certain strain may be produced by vocal structures, the epiglottids of which are quite variable in shape.

However, it should not be assumed that the high frequency fundamental component noticed particularly in the case of the mutant

albino rat is necessarily produced by vibration of the vocal cords. Almost all specimens tested exhibited a relatively large component having a frequency between 2000 and 3000 cycles per second. Structural features of mouth and throat cavities may tend to emphasize this frequency. In the case of the high frequency fundamental, it may be produced by the passing of air over an obstruction as in an ordinary whistle, the sound not originating at the vocal cords at all.

It would appear that the fundamental frequency is determined by some sort of vibrating structures such as the vocal cords themselves, the physical nature of which is rigidly determined by the genetics of the individual, and bearing distinct strain variables. This suggests that the vocal cords differ in different strains, at least in length and possibly also in other qualities. Whether or not such physical differences exist histologically, remains to be determined.

It appears also from other evidence, however, that this is probably the case. For example, it is well known that a vibrating wire or fiber emits a tone the fundamental frequency of which is inversely proportional to its length. Suckling mice have tiny, high-pitched voices and short, fine vocal cords. As the cords thicken and elongate during development, the pitch of the voice decreases concomitantly with an increase in raucousness.

A thorough histological study ought to reveal correlations of physical structure with position of the fundamental frequency, and possibly the correlation with more subtile vocal characteristics.

SUMMARY

1. We have recorded and analyzed the voices of rats from eleven distinct strains marked by Mendelian genes.

2. The time qualities of transientness, sustainedness, and varying tone are at present unintelligible because several of these qualities may be found in the voice records of the same individuals. But such variability may be correlated with the nature of the immediate psychological stimulus occasioning the vocal outcry.

3. The number of harmonies seems to increase with increase of auditorily distinguishable harsh quality in the voice.

4. In general, the number of peaks of large amplitude may be said to correlate with quality in that whereas other strains tend to several peaks and have non-whistle quality, the mutant albino voice has but one predominant peak in the animals tested and tends toward a whistle-like voice.

5. Position of the fundamental frequency appears to be the most strain-constant of all the voice qualities, the audibly distinguishable nature of the voices of gray, black piebald, and mutant albino, for example, being corroborated by our wave length analysis.

6. It is noted that quality of voice is hereditary, that single coat-color genes can modify it materially. When two modifying genes

may exist in the same individual, the tendency of a characteristic location of the fundamental of one type may actually dominate over the tendency toward another characteristic location.

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THE ORIGIN AND MEANING OF THE SWASTIKA

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When I asked Ikwaniktipippi and my other Cuna Indian friends the name of the swastika in their language, they said "kikir" (octopus) and added that to them it had no religious meaning. They explained that it was a commonly used basket-weaving design and mola blouse design, representing the arms of an octopus. Thus, it is possible that the Cunas received the swastika (gammadion) from some other culture without any significant meaning being transmitted with it, or it is possible that they have forgotten the meaning. Maybe it is too sacred for them to divulge information about it. More investigation is definitely needed, although I suspect that to them a cross mark basis of the swastika which they use against evil is the Tree of Life. Such cross-marks are sometimes painted on the doorposts in the case of very serious illness as protection against lethal devils of disease.

Other Indian tribes will admit that the swastika does represent the Tree of Life, and Olowitinappi, the Cuna Medicine man of Mulatuppu, said it could be a corn plant as seen from above. Of course, the corn plant was to many American tribes the Tree of Life. However, at its origin the swastika could not possibly represent the maize plant if the gammadion originated in Asia Minor as some have suggested and as may well have been the case.

The most detailed explanation of the origin of the swastika that I have seen is given by the Navajos who say that when the Great Flood took place a cedar log was shot out of the center of a white cottonwood log, and one came to lie at right angles to and on top of the other. Together they started to spin and hence the bent tips represent the motion of the water. The two logs went whirling about in that crossed relationship on top of the water, and upon them (serving as the Ark) mankind was saved.

We are most interested in the action of this explanation, the fact that the Tree of Life was spinning in a whirlpool. The Hindus explain that the Lotus Lily of Eternal Life (Tree of Life) is revolving about a vertical axis on top of the water forever. The Cunas say that the vulva of the Earthmother is God's Whirlpool. "The Tree of Life is still turning and that is why birds, fishes, and other animals still develop and multiply," says Chief Ikwaniktipippi. This all seems to tie together.

The swastika, then, could represent motion of the Earthmother's Whirlpool or vortex of generation and also the Tree of Life. With these facts in mind, let us examine some of the Hissarlik discs of some 3,000 B.C. figured by Schliemann and also by Ludwig Müller. They are presented in D'Alviella's THE MIGRATION OF SYM-

BOLS. These discs may have been buried with the dead to insure spiritual rebirth or resurrection into the afterlife just as cowries, symbols of the Earthmother's womb and vulva, did in neolithic burials of Asia and elbow-knee plates depicting the Earthmother in childbirth seem to have done in Indonesia and South America (see figure 18). Certain of the Hissarlik discs, when properly arranged, demonstrate an evolutionary series that sheds considerable light on the origin and meaning of the swastika about which there have been so many unlikely guesses.

In figure 1 we see a central circle from which radiate motion lines bent at the tips and also the symbols of flowing water. If this is compared with pictures made by Incas, Mayas and Cunas (See figures 13, 14, 15, and 16) it appears that this is a picture of the sacred birth scene featuring the Whirlpool of the Earthmother.

Figure 2 shows the Earthmother's vulva, whirling motion lines, and three buttons with a central dot. The buttons are suspected of being placentas, as we shall show. The dot in the center is where the umbilical cord (Tree of Life) was attached.

Figure 3 shows well the gushing of the Water of Life and the Trees of Life floating upon it.

Figure 4 shows a central cross within the vulva, with four buttons and four swastikas. The flow of water at the periphery is depicted especially well.

Figure 5 shows vulva, swastikas, and water flow.

In figure 6 the Four Rivers of Life are well depicted flowing from the Earthmother's vulva. Four buttons are symmetrically arranged.

Figure 7 is a "swastika" from a Lycian coin. It appears to correspond to the stream representation in figure 6.

Figure 8 shows no water flow lines, but it does represent the Earthmother's vulva, three Trees of Life and three buttons with a central dot. Thus, the number of buttons tends to be the same as the number of Trees of Life.

Figure 9 shows the Earthmother's vulva, the water symbols, and bears but one Tree of Life. The Tree of Life is placed directly over a button. Thus, the Tree of Life grows out of the button. This confirms our identification of the button as the placenta and the swastika in its final form as the Tree of Life viewed from above.

D'Alviella, on the basis of a Hindu profile picture, interpreted this last disc to represent the Hindu Tree of the Sun bursting forth from the primeval egg. We feel that this is too advanced an explanation, although from the standpoint of the swastika in both interpretations, it becomes the Tree of Life.

In figure 10 is shown a Javanese coin published by D'Alviella. It is of a rather common type in which the Tree of Life grows out of a square, sometimes quartered. At other times it appears to be a box. In either case it represents the earth and reminds one of the Bodhi Tree Shrines of India in which the box from which the Tree grows represents the Earthmother's uterus.

Figure 11 is a Mayan type glyph standing for birth. It shows lines at the entrance of the uterus, much as one sees in figure 1, that might be interpreted as action symbols. However, the details of other glyphs make it probable that these are defoliated Trees of life.

Figure 12 shows a rock painting reported by Thomas A. Cumming from Upper Hat Creek Canyon between Ashcroft and Lillocet, British Columbia. The Tree of Life with four branches is shown to the right emerging from the Earthmother's Mons veneris. Apparently, the River of Life flows away from the Tree of Life to form the sacred lake. Various animals are present. A warrior (possibly the hero Iki-ap) is shooting at a sacred, legendary bird out of whose head grows the Tree of Life to show that it is immortal, just as the Potowatomi represent the Sacred Twins, Tiharonhiawagon and Towischaron, with the Tree of Life growing out of their heads.

Figure 13 shows a South American helmet featuring the Earthmother's vulva guarded by two serpents and backed by the Rainbow Symbol of the Protective Placenta.

FIGURE 13. *Placental Monster guarded by jaguars and bearing Jaguar (Sungod) design on clothing. Note the Birth Scene symbol on the head, including snakes (Umbilical Cord), aperture (Earthmother's Vulva) and behind the aperture the Rainbow symbol of the Placenta. Capa, Car-Huaz. Redrawn after Tello.*

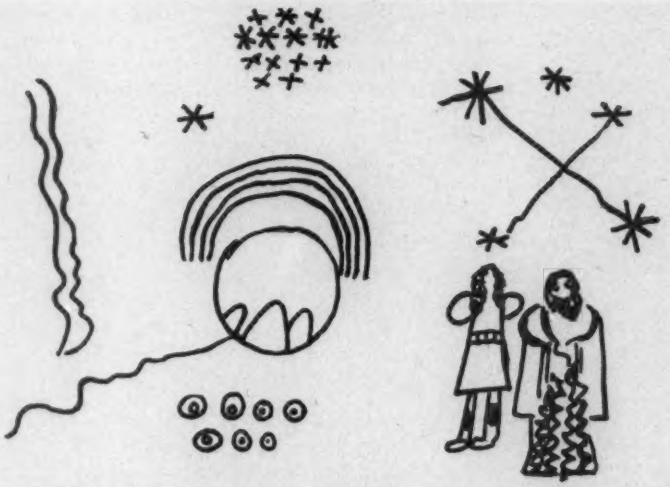

FIGURE 14. *Inca drawing by Salmacaya from the time of the Conquest showing the Earthmother's genitals (Pacha Mama) with the River of Life flowing from them to the Sea. Below are seven "eyes" which probably represent the seven "mother pots" shown in Figure 4. "Eyes" and "pots" may symbolize the seven stages of development of the seven days of Creation. Above Pacha Mama is the Rainbow symbol of her placenta. To the right is the Son of God and his wife (really an Earthmother) in menstruation. Redrawn after Tello.*

Figure 14 is a picture made by the Inca, Salmacaya, at the time of the conquest. The River of Life is flowing to the sea from the Earthmother's great vulva which is surmounted by the Sacred Rainbow.

Figure 15 is a Cuna interpretation of this birth scene with Trees of Life, Earthmother's vulva, the Rivers of Life, and the rainbow which is really the Earthmother's placenta.

Figure 16 shows Stirling's stele #5 from Izapa, depicting the Maya Tree of Life springing from the Earthmother's genitals, the Water of Life flowing away to form the ocean and the placental monkey rather than the placental rainbow symbol.

There are a number of "Earthmother" figurines from Hissarlik described by Schliemann. A swastika appears on the Mons veneris of the one we reproduce here, reminding us of the Biblical statement: "And in the midst of the Garden the Tree of Life." (See figure 17)

The discs from Hissarlik suggest the triskelion made of shell and recovered from a Tennessee mound. It will be remembered that shell is a symbol of the Earthmother. In this connection the symbols used by the Kee-way-den lodge of the League of Nations of North American Indians should be mentioned. The arch of heaven is shown

FIGURE 15. *Lower center, Tat Opa (Adam) during his gestation in the Earthmother's uterus. Note vulva and Tree of Life. Lower right, in profile, Kwelopunpai, the Frog Woman midwife. Beneath her is Olokwenmastili, the grasshopper messenger of God. and Olokukurtilisop (Earthmother in butterfly form), also Olowaipippilele and wife, Olowaiili. Left, the Planet and Fixed Star brethren of Olowaipippilele armed for battle. Drawing by Chief Ikwaniktipippi.*

and under it the "all seeing eyes" of the Skyfather. Beneath these is the horizontal line of Mother Earth. Upon the Earthmother line rises the Mount of Gestation having on the front of it the turning square of the Earthmother's Whirlpool, as it is called by the Cunas. (See figure 18). The High History of the Holy Grail is now known to be a Druid religious parable glossed over with Christian allusions to hide its true meaning from violent priests and knights who spread their gospel about Glastonbury by means of the sword. In this account the Turning Castle may well represent the vortex of generation.

We have demonstrated in this paper that the representation of the Earthmother's Parturition Scene was a very common phenomenon among adherents of early fertility religions, and that by interpreting the Hissarlik discs in the light of this fact, we can account for the origin of the swastika at the Troy of Schliemann as a representation of the Tree of Life.

We shall want to ask the Cunas about the symbols on the Hissarlik discs.

I am deeply indebted to Mrs. Ruth Verrill for providing me with drawings of and information about the Sumerian and Maya glyphs.

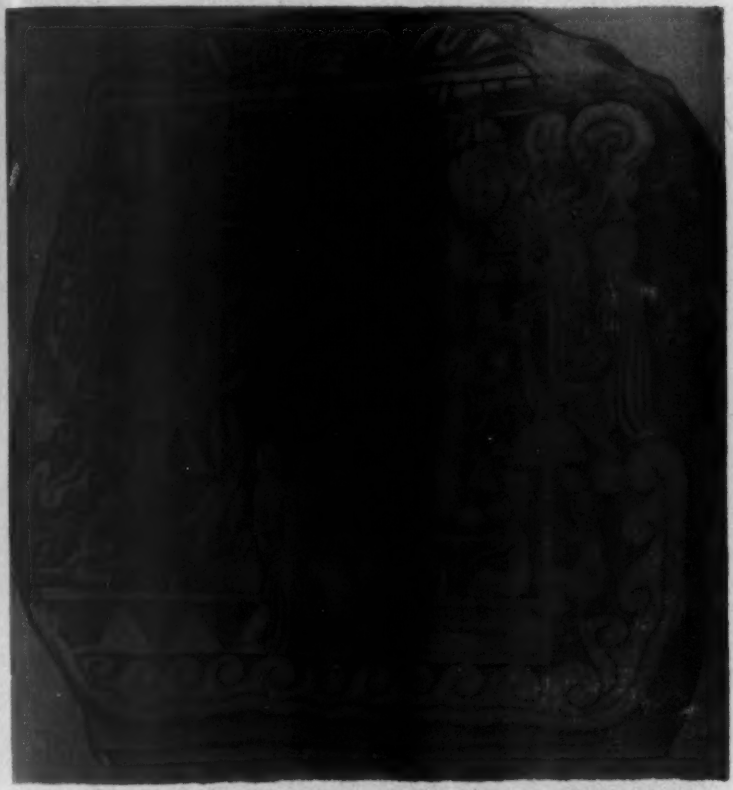

FIGURE 16. *Dr. W. M. Stirling's Izapa Stela No. 5. Reconstructed from a photograph provided by Dr. Stirling. This elaborate monument shows the Tree of Life beside the Earthmother's Genitals (zig-zag and slit). ... The Water of Life gushes forth to form the Oceans of the World (wave sympol). The "Two Headed Sundog" stands to the right of the Tree of Life with his Sacred Flute. The Two Headed Snake frames the picture. The Fish are symbols of the Earthmother. The Jaguar nose and teeth symbols represent the Physical Power of God. Chief Ikaniktipippi says that the bearded figure at the lower left is a Merman (Ansu), and that before him is a new Tree fo Life. At the lower right is a monkey that sometimes symbolizes the Placenta Dragon. He holds a parasol which would be taken by the Cunas to be the Umbilical Cord and the Foetal Membranes of the child.*

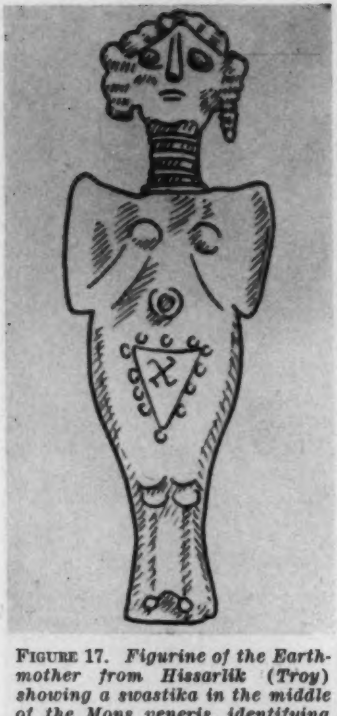

FIGURE 17. *Figurine of the Earth-mother from Hissarlik (Troy) showing a swastika in the middle of the Mons veneris, identifying the swastika as Tree of Life turning in her generative vortex, just as the Lotus turns in India and the Tree of Life does in the religious philosophy of Indians of both North and South America.*

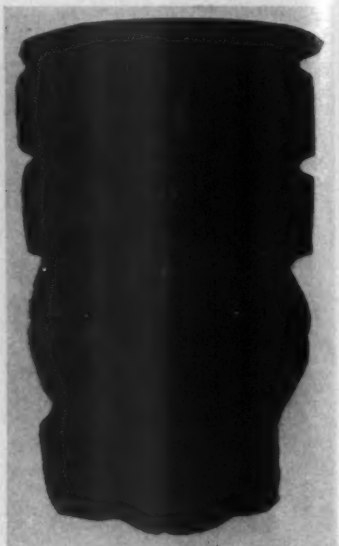

FIGURE 18. *Plate of bone recovered by Jerry Doyle from a grave at El Volcan, Chiriqui, Panama. The carving depicts the Earthmother in childbirth, a symbol of ressurection, or rather, birth into the Afterlife.*

THE MI-DI MEDICINE BOOKS OF LONE EAGLE

CLYDE KEELER
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and

Marie Mellinger, formerly
Mrs. Lone Eagle

with comments by

Medicine Chief Shup-She (Howard L. LaHurreau) one time
President of the League of North American Indians

Seldom is it possible to place on record the contents and meanings of Indian medicine books because they are sacred, and what is sacred is secret. Such notebooks are most frequently buried with their owner and the meanings of their pictures are seldom revealed. Suffice it to say, however, that a continuity of religious ideas runs through all of them just as is found in the articles of faith of most Christian ministers, although taught by different schools of theology.

Lone Eagle studied Potowatomi Mi-di medicine of the cultural Hero Wes-sha with Harry Nabakah of the Forest Potowatomi who had become deaf and accordingly, when he prepared the texts he placed a few explanatory words in English upon them which give clues to their meanings, an advantage usually not found in such notebooks. Nabakah's wife added other explanations and still fuller descriptions of the meetings have been inserted by Mrs. Lone Eagle. Comments by Medicine Chief Shup-She are placed in italics.

There are three of these notebooks, now in the possession of Mrs. Mellinger. The first concerns the Afterlife, the Great Serpent of Evil, and the Great Turtle. The second notebooks describes the activities of the Evil Tree Creature. The Tree Creature fights Thunder, owns a swampy lake on top of a hill, becomes a man, gives black magic medicine to Indians, becomes the Black Bear of the Coffin, circles about the coffin, breathes out fire and light at night, changes to turkey, cat, dog, fox, owl, naked man so that he can travel faster at night. Then comes pictures of two medicine huts, Nanabush on the Flood, Whiske (wrongly identified) remaking the earth after the flood, evidence of punishment by fire, etc., of white men who made fun of Indian religion. Then follows pictures of strange people, women without wombs, Whiske, Brother, Dog, Snowman, Brother (Tarachiawagan) as King of the Dead.

The third notebook contains pictures of the Great Evil Serpent, peyote medicine, "Menominee reservation too bad peyote eat," Tree Creature, Bad Horse, Black Thunders kill Snake, Snake turns to deer, lake of Serpent looks like brown tea-water. Serpent looks like big fish to irreligious white men. There follow pictures of Lightning Arrow, Arrow strikes telephone pole to get at Evil Tree Creature

underground who enters the earth at springs. It describes Thunder-woman who was born near Manetown and was killed by lightning. White man is destroyed by Black Thunders. White men have hunting accidents due to the spirits of animals who know of their plans to kill them. The cannibalistic giant Nishnahbahnumwet or Heart-ear is depicted. Once he was overcome by Whiske (probably by Whiske's Brother Tarachiawagan). Jimnadoo the Serpent is shown in Muddy Lake, at whirlpools and in falls. He and his fellows eat Indians sucked down to his medicine Lodge under the lake. Pictures show Whiske going into the earth to meditate and perform ceremonials. There are pictures of medicine lodges (tishkayon) and the Indian Eaters: Serpent, Giant, Cat, Tree Creature. Other pictures show that sin is overcome through the rites and teachings of the medicine lodge. There is a description of the Dream Dance. A house is struck by lightning because Black Thunders is trying to hit the Tree Creature who is hiding in the earth under it.

We shall reproduce here a number of the notebook pictures and describe them.

Indians in general need no proof of life beyond the grave. It is taken for granted. The Life, Soul or Spirit of a person that lives on after death is called the "living dead person." In figure 1 the hand of the "living dead person" is shown in a whirl of blue lines, reaching back to earth to obtain the spirit nourishment of the food that is burned during four nights at the grave. The "living dead person—eat—noEat meat" caption refers to the spirit of the dead eating only the spirited essence of the sacrificed food.

The big, sacred waterdrum (symbol of Earthmother's genitals) had been set up near the shore of Rice Lake called Big Swamp by the Indians. Wild rice growing there was guarded by the spirit of Great Turtle who lives in the earth, entering his home through a hole in the middle of the swamp. There was a great storm in 1922 that destroyed most of the crop. The caption "little bit. well" means that some of the crop was saved. "More home. Big turtle. door" means that although Swamp Lake is the Turtle's headquarters, he has other subsidiary homes. See figure 2.

The Serpent is the Old Dragon, actually the placenta of the Earthmother. The swamp is her generative organs on the Hill of her Mons veneris.

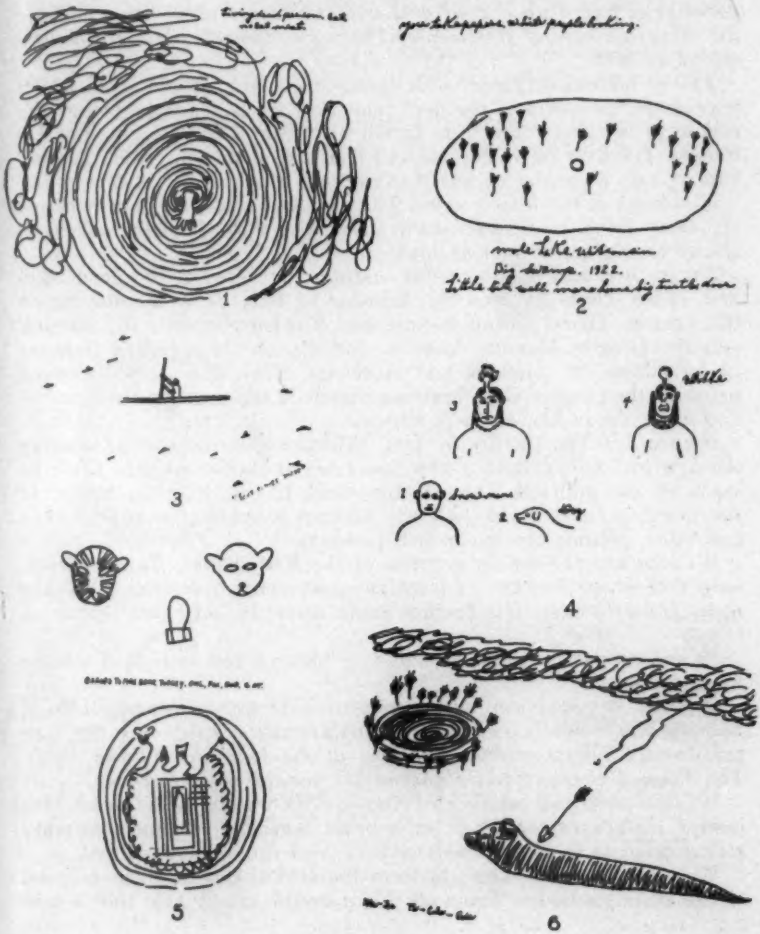
The explanation with figure 3 is "Picture of creature, when it happen before this earth was made. This is the person who save all the animals from drowning. They say it was deep as the tallest trees four times more." This, of course, is Nanabush (Potowatomi Noah) saving the creatures on his log at the time of the Great Flood which is actually the amniotic fluid of the Earthmother when she brought forth the plants, animals and man.

Nanabush was less important than Tarachiawagan (the Good Twin, actually the Sungod). Nanabush (Manabozho) was a man, not a god, but the younger brother of the Winds or four powers of direction.

He was a son of the West Wind and an Algonquin woman (Earth-mother ?) at so ancient a time that the Algonquins were then living in Mexico or our Southwest, say 50,000 years ago.

Figure 4 shows "Snowman and Whiske and Dog. Whiske's brother number 3 and the dog is cousin to the Snow and the snow is the father of Whiske."

Snowman is not the Creator, he and Heart-ear are creations of the ages. One such ate humans. Sundog Sons, Wari-Wilkas, were in time



to become dogs. Hence Dog-soldier Societies. Wari-Wilkas, were Sons of the Sun, guardians of the Sun's power, as the Holy Twins, the Four Winds. The wildest animal in the jungle was picked to carry the name Wari-Wilkas.

At the top of figure 5 are shown cat forms that the Tree Monster may take, sometimes brown, sometimes black. It may take other shapes as well, such as listed above. Below these cat heads is the bag of Black Magic bestowed upon Indians who serve the Tree Creature.

This is the old dragon, able to change form, but I think your informant is mixed up a good deal with Christian ideas from some of his other misleading statements. The horse (form) indicates a very mixed up idea.

At the bottom of figure 5 is shown the black, magic Bear which may circle the coffin of the dead man four times. Then he brings the corpse to life and forces him to tell all, after which he rips out his tongue. The bear never forgets and if a person says anything against him he may imprison or kill that person.

Mac-kwah is the Bear's name. The idea was that bears could throw off their skins, and underneath were men. Bear-Human marriages etc. all took place in ancient days.

Figure 6 represents the never ending war between the good Sky-god, Black Thunders, and the Monster of Evil. It is the slaying of the dragon: Osiris killing the crooked, fleeing Serpent, Bi, Marduk and the Dragon Musshu, Yawveh and Rahab the Crooked Serpent or Leviathan, St. Michael and Apollyon, Thor and Apla the aged priest of the Dragon Cult. Matretacokeade is the name of the Serpent and his home in the earth is shown.

Figure 7. "The picture of him, Whiske, when he's alone making the new ground to build a new one from the other picture after he saves all the animals. This creature said If this happens again. If the world is flood again, he's not making it again. Because Indians and other persons are too foolish nowdays."

Wi'saka was the evil or negative of the Holy Twins. He remodeled, only that as his brother (Tarachiawagan) made butterflies, Wi'saka made houseflies etc. His brother made roses. Wi'saka put thorns on them.

In order to put woman in a bad or lower place he caused woman to be catamenial.

Wi'saka invented war and warbags. Some say he invented Mi-di, but this isn't so. However, he did gain quite a hold over the clan priesthoods and they still use some of his teachings in the Mi-di. The Plumed Serpent and Hansomelake fought these teachings.

Wi'saka used evil magic to bring a dead woman to life and thus gained stature in the Mi-di as a great man. The Potowatomis are still divided as to whether he was part good rather than all bad.

Wi'saka is said by some to have founded the Mide-Oken religion of the Medicine Lodge. From all this it would appear that the picture

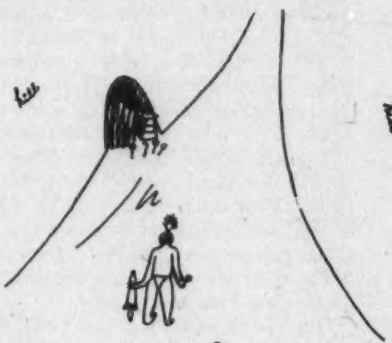
in figure 7 should have been captioned "Tarachiawagan remodeling the earth after the great flood."

Figure 8. As with many peoples, the Potawatomi Sungod and shamans reenter the Earthmother's womb for inspiration, healing and meditation. This is the purpose of the kiva of the Navahos. It is wrestling with and subduing the Spirits of Evil in the Wilderness.

In figure 8 Wi'saka is shown descending into the Womb of Inspiration of our Great Mother Earth. Her genitally symbolical water-drum stands at the entrance in company with the curved, phallic drumstick and the uterine rattles. The Tree of Life is on his head and he carries what appears to be a fox skin.

Here again the coyote, wolf, lion, fox and other commonplace animals find they have taken the job of the Wari-Wilkas or Guardians of the Sun.

Figure 9. Whiske's younger brother is King of the Dead in the Land to the West, much as Osiris is. There the souls of the righteous



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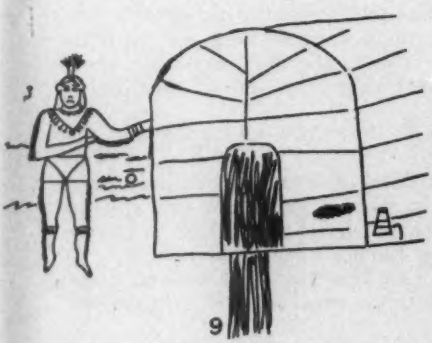

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gather together to carry out rituals and take part in the sacred dances and other ceremonials.

The brother of Wi'saka was the Good Twin Tarachiawagan of the Iroquois, the Creator or Semi-Creator god who led men out of the Earthmother's body. He is not the Bright and Morning Star as this title was reserved for the much later holy man Plumed Serpent. Because of the mixing of many tribes in pre-Columbian America, those stories got confused here. In Maya-land they have a better understanding.

Figure 10 is a summary of religious symbols. Heart-ear, the horrible giant, is depicted. His heart hangs on his left ear. When he is shot through the heart he dies, but after three days he rises again on the fourth. There is shown the sacred water drum with its curved drumstick and the three accompanying rattles. To the left is the Mi-di medicine hut by the Tree of Life that reaches from the Womb of the Earthmother clear up to Heaven, the home of the Skygod or Sungod. The Mi-di hut is guarded by the Great Turtle and a medicine man is shown prostrate in a trance within it, communicating with the totemic Spirit of the Great Turtle.

The turtle clan were guardians of the temple. They took their power from the dragon (Great Turtle) and that is the reason for the guardianship. Heart-ear is a sub-human who ate men, no doubt another tribe who in time became a god or devil.

Certain other items in Lone Eagle's Mi-di Medicine notebooks should be mentioned. The Great Serpent of Temptation was said to be three miles long, but by Indians employing the Dream Dance he had been reduced to one mile. But he simply divided himself into three pieces and now influences more territory. Then he was further reduced to one half mile in length and had to content himself with destroying fish in the lake.

Once some nearby Chippewas changed the ancient rituals and as a consequence the Potowatomi water drum set up on the shore of Big Swamp Lake was washed away in a storm brought in anger by Black Thunders.

One note tells of strange Indians to the West "just smooth from their bottoms (down), but from their waist to head are built like us." They are called Kepdeade. Also to the West are nine women without wombs. A white man got a baby from one of them but he died from the experience.

The Tree Creature often takes the form of a Chipmonk and then he is a great spy.

Mention is made of the SweatBath of Purification, presumably baptism with the Earthmother's amniotic fluid into a new spiritual life, since the sacred, hot stone upon which water is dashed to produce steam is actually a symbol of the Earthmother's bones.

The Indian Eaters, Giant, Lion, Cat, Water Serpent, take on human form, attend the medicine dance, take the sweat bath of purification.

pretending to have great virtue and sincere religion—while always on the alert to do evil, even causing sickness and death.

There are many cavernous entrances to the womb of the Earth-mother. These are called pewaubbicks. Each yields something of value to Indian cultures: copper, flint, pipestone, lead, etc. The area about these entrances to treasure caves is sacred, and tribes never fight there.

There are listed a number of heresies and their divinely instituted punishments. In one notebook Peyote eaters are said to turn into snakes, toads and lizards.

A farmer who wanted to get in his hay before a storm, fired a shotgun at Black Thunders. In return, a hurricane was sent by Black Thunders which destroyed the farmer's hay and his house. Presumably the farmer was also destroyed as he was never seen again.

Animals hear what we say, and they dislike bad remarks made by us about them. Once a woman made a bad remark about a bear. Later, a bear chased her and tore her clothes off. When he caught her she fell to the ground and remained motionless. The bear sniffed her all over from foot to head. When he smelled her head he ran away.

Once a woman, who practiced black magic of the Tree Creature and thereby killed a number of people, said strange words to the great clouds of Black Thunders. Black Thunders sent a fireball to destroy her. She ran to her hut. "The Thunders ball start to follow her into her hut and it strike her to pieces, you know she was all crash up, just like flour."

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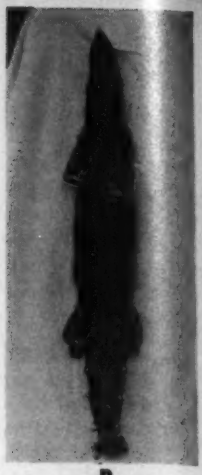

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FIGURE 11. 1. *Lone Eagle's personal Mi-di Medicine Lodge drum. There are drum heads on both sides. One side is bare and the other shows a picture of the Mi-di medicine lodge standing between the four sacred cedar Tree of Life. The protector totem Turtle or Placental Monster (made of wood) is appended from the drum, as is a cloth bag to contain medicines or fetishes.*

2. *Lone Eagle's sacred Water Drum, representing the uterus of the Earth-mother. It is made of cedar and is painted light green. Upon it lies the sacred drum beater, a phallic symbol of the Sungod's fertility. At four sides of the durm are tied into the protruding leather of the drumhead cowry shells from the Atlantic Ocean as kteic symbols of female fertility. These are said to represent birth into the four ascendant grades of the Mi-di lodge. A small plug just above the cloth band is inserted into a hole through which water is poured into the drum to represent the Skygod's semen, and through which hole breath is blown to represent presumably atmosphere or the "Breath of Life."*

3. *This is the sacred otter skin in which two bags of fetishes or medicine are kept by the Mi-di medicine men. Upon his death the bags of medicine are buried with the medicine man, but the sacred otter skin must be returned to the tribe... Presumably the beaded leaves over the paws and the leaf-and-bud design on the tail represent the Tree of Life and the otter skin is the Placetal Monster of the Earthmother in its fertility sense. In one dance the medicine men gave these skins to their wives and as the wives danced past the wife of Lone Eagle they touched the noses of the otter skins to her chest... They said that this would bring to her the greatest blessing on earth, presumably fertility.*

4. *A beaded fetish bag showing four copies of the Thunderbird.*

5. *Reverse side of the beaded bag shown in Figure 4. This shows four copies of the wildcat-like Tree Creature. These two animals are always at war, representing the battle of the Sungod with the Earthmother's Placental Monster, or good against evil.*

OAK RIDGE STUDENT TRAINEES

Oak Ridge, Tenn., June 22—Twenty aspiring young scientists are spending the summer in Oak Ridge, where they will get a glimpse of the futures they have chosen.

This select group is composed of science students who have finished their junior years at small colleges in the South and Southeast. During the summer before their final year in college, they have been chosen as "Oak Ridge Student Trainees," and are now working in various laboratories, depending on their selected field of study.

This student training program, which was initiated last year, is administered for the Atomic Energy Commission by the Oak Ridge Institute of Nuclear Studies, in cooperation with Oak Ridge National Laboratory, where most of the students are working.

Ten of the young scientists have joined the ORNL Biology Division, four are with the Chemistry Division, and three are in the Physics Division. Two have been assigned to the Medical Division of the Oak Ridge Institute of Nuclear Studies, and one is working at the ORINS Special Training Division.

A special orientation program was held last week for the student trainees, who were welcomed by Dr. L. K. Akers, ORINS research scientist. An orientation address was delivered by Dr. C. S. Shoup of the Atomic Energy Commission, whose field is biology. After a tour of the American Museum of Atomic Energy, the students heard a brief explanation of the AEC Oak Ridge Operations Office by Ned Williams, who is deputy assistant manager for operations. Five scientists from the five divisions where the students will work discussed the activities of their particular organizations: Dr. J. L. Fowler, ORNL Physics Division; Dr. E. H. Taylor, ORNL Chemistry Division; Dr. S. F. Carson, ORNL Biology Division; Dr. R. T. Overman, ORINS Special Training Division; and Dr. G. A. Andrews, ORINS Medical Division.

In the afternoon, the students embarked on the first day of their jobs, entering the careers to which they have chosen to devote their lives.

OAK RIDGE STUDENT TRAINEES — 1959

Acton, George—Centenary College of Louisiana, Shreveport, La.
Barnes, Roslyn—Georgia State College for Women, Milledgeville, Ga.
Byrd, Charles L.—Centenary College of Louisiana, Shreveport, La.
Cook, Verna Mae—Alabama College, Montevallo, Ala.
Courtington, Frederick—Rollins College, Winter Park, Fla.
Flora, Robert M.—Bridgewater College, Bridgewater, Va.
Goldstein, Marvin N.—Western Maryland College, Westminster, Md.
Guillory, William A.—Dillard University, New Orleans, La.

Hedger, Wayne L.—Carson-Newman College, Jefferson City, Tenn.
Hite, Adeline—Columbia College, Columbia, S. C.
Lanier, Nancy—Randolph-Macon Woman's College, Lynchburg, Va.
Leslie, Allen L.—Dillard University, New Orleans, La.
Mack, Rebecca—Limestone College, Gaffney, S. C.
Pope, Norton A.—Ouachita Baptist College, Arkadelphia, Ark.
Robinson, Don Morton—University of Chattanooga, Chattanooga, Tenn.
Ruble, Betty Jane—Western Kentucky State, Bowling Green, Ky.
Sapp, Sally Ann—Winthrop College, Rock Hill, S. C.
Wagner, Sondra—Maryville College, Maryville, Tenn.
White, Joe Davis—Mississippi Southern College, Hattiesburg, Miss.
Yundt, Joanne—The Woman's College of the University of North Carolina, Greensboro, N. C.